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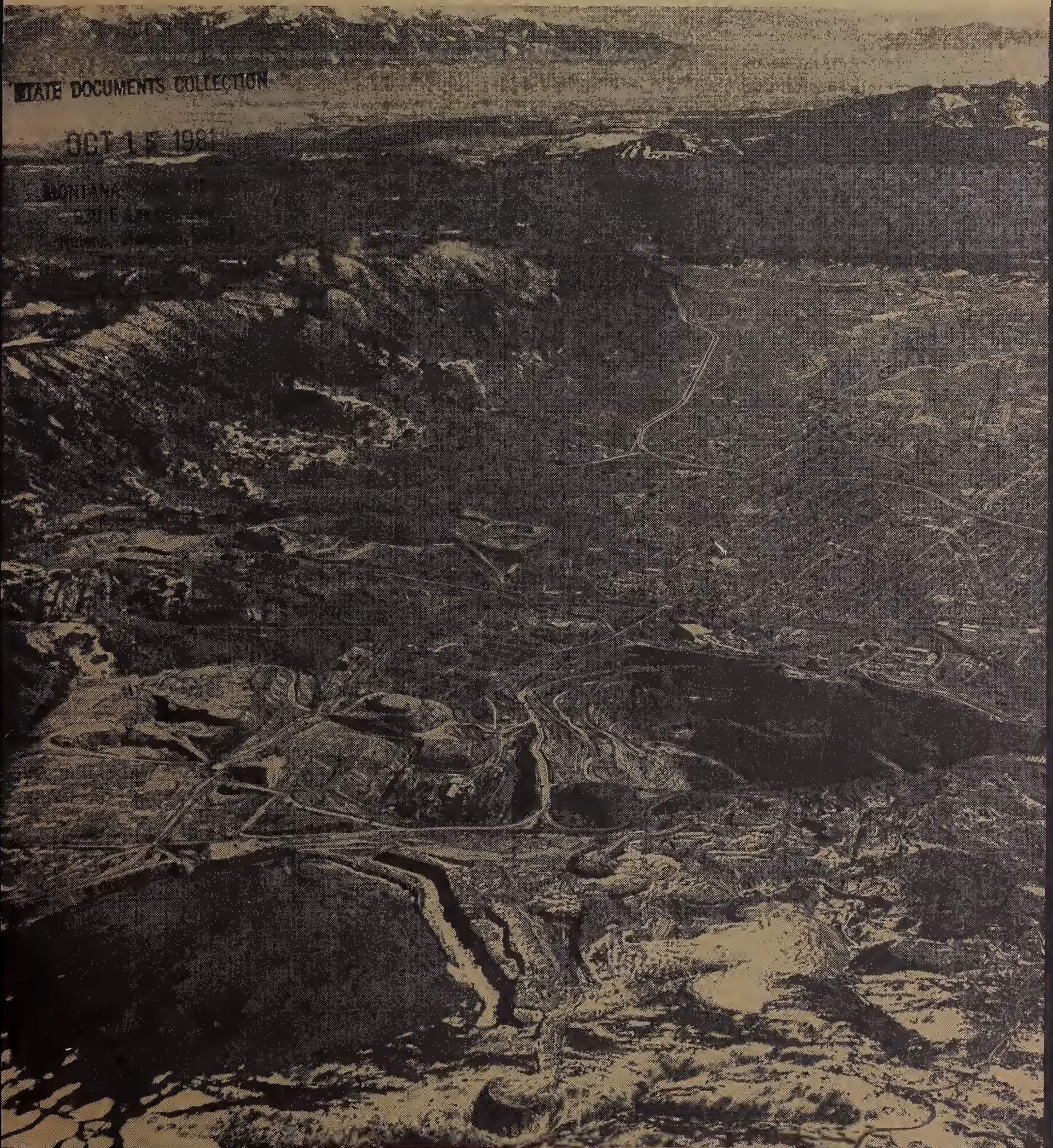
Environmental Impact Statement

Proposed South Dump Expansion - Butte, Montana



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Draft Environmental Impact Statement

Proposed South Dump Expansion

Butte, Montana

Montana Department of State Lands

June, 1981

Gareth Moon, Commissioner

SUMMARY

1. Action under consideration: Anaconda Copper Company has applied to the Montana Department of State Lands for a permit to expand an existing waste dump and construct a new waste dump at its Berkeley mine at Butte, Montana. The Commissioner of State Lands must decide whether to approve the permit as applied for by Anaconda, deny the permit, or approve the permit subject to stipulations.

2. Brief description of the company's proposal: Anaconda proposes to expand an existing waste rock dump (called the south dump) east of Continental Drive and north of the Hillcrest subdivision. The company also proposes to create a new waste rock dump (called the north dump) in Elk Park Canyon. The dumps would allow the company to continue mining the Berkeley Pit until about the year 2000, or possibly longer if economic conditions allow. Waste rock would be dumped at the south dump from about 1981-87, and at the north dump from about 1987-91. The dumps would be revegetated to support the proposed postmining use for watershed and small mammal habitat.

3. Summary of impacts: during active dumping, sediment eroded off the waste dumps would be captured in ditches and treated in the Berkeley mine wastewater system. After reclamation, however, erosion rates on the south and west facing dump slopes would be higher than the expected rate of soil formation. This erosion, combined with the droughtiness of the soil and alluvium used to cover the dumps, could limit revegetation success to moderate at best. Wildlife populations in the proposed permit area would be slightly reduced in number and diversity.

Short-term hydrologic impacts from the waste dumps would be minimal, because the company would maintain its proposed surface runoff diversion system, and because any contaminated ground water would probably be captured in the Berkeley mine pumpage. Long-term hydrologic impacts (hundreds of years from now) could be severe because the runoff diversion systems would eventually fail. The Berkeley Pit would intercept runoff from the north dump, but streams cutting into the south dump could eventually deposit sediment in what is now a residential area.

Impacts on air quality, social and economic conditions, and esthetics would not be severe, largely because the mine is an ongoing operation that would not introduce new kinds of impacts to the Butte area.

4. Alternatives considered: approval of the mine operating permit as proposed, denial of the mine operating permit, taking no action, approval of an operating permit containing modified mining or reclamation plans, and approval of the mine operating permit as proposed with stipulations.

5. Short-term (0-20), Long-term (approximately 20+) Reclamation Costs: the short-term reclamation costs will be born by the Anaconda Company. However, if and when the reclamation bond is released and the dump begins to erode without intensive management, the cost of reclamation will be borne by one or more of the following: local residents, city-county, state, or federal government agencies.

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CHAPTER I

DESCRIPTION OF THE PROPOSAL UNDER CONSIDERATION

This environmental impact statement (EIS) discusses Anaconda Copper Company's application for a permit to dump waste rock in two locations from its open pit Berkeley mine in Butte, Montana. A permit from the Montana Department of State Lands is required under the Montana Metal Mine Reclamation Act (formerly the Hard Rock Mining Act) before the company can use the proposed dump locations. If the Department issues the permit, the company would be able to expand the Berkeley mine to the east. Because Anaconda's proposal may significantly affect the quality of the human environment, the Department of State Lands has determined that an EIS is required under the Montana Environmental Policy Act before a decision on the permit is made.

A. HISTORY OF THE COMPANY'S PROPOSAL

In June, 1974, the Anaconda Copper Company applied for a mining permit covering about 500 acres east of its Berkeley Pit copper mine in Butte, Montana. The purpose of the permit was to allow construction of a waste rock dump for continued open pit mining. The Department of State Lands issued an EIS on the proposal and approved the permit (#41A) in December, 1975. In March, 1976, the Hillcrest Homeowners Association, primarily representing residents in the Hillcrest subdivision south of the proposed dump, filed suit to revoke permit 41A. The Association did not seek a preliminary injunction against Anaconda; work on the dump began in late summer of 1976 and continued during court proceedings.

On October 16, 1979, the Montana Supreme Court ruled that permit 41A is invalid and prohibited continued use of the permit area until a valid permit is issued by the Department of State Lands. The Supreme Court, in overturning a District Court decision, ruled that the mining plan submitted by Anaconda did not meet the requirements of the Hard Rock Mining Act because: 1) it covered only 90 acres of the 500-acre permit area; 2) it did not adequately describe climatic conditions in the area; and 3) it did not describe proposed uses of the land after reclamation.

The mine dump, known variously as the Hillcrest dump and the south dump, grew to about the 5,800 foot elevation (approximately 175 feet above its base near Continental Drive) before work was stopped by court order. Anaconda is now dumping waste rock near its tailings pond north of the Berkeley Pit (fig. I-1). The company considers this a temporary dumping location only.

B. SCOPE OF ANALYSIS

On April 2, 1980, Anaconda applied for a mining permit covering 428 acres in essentially the same area as the previous 41A permit. This EIS analyzes the new permit application (no. 158). Figure I-2 shows the permit application area.

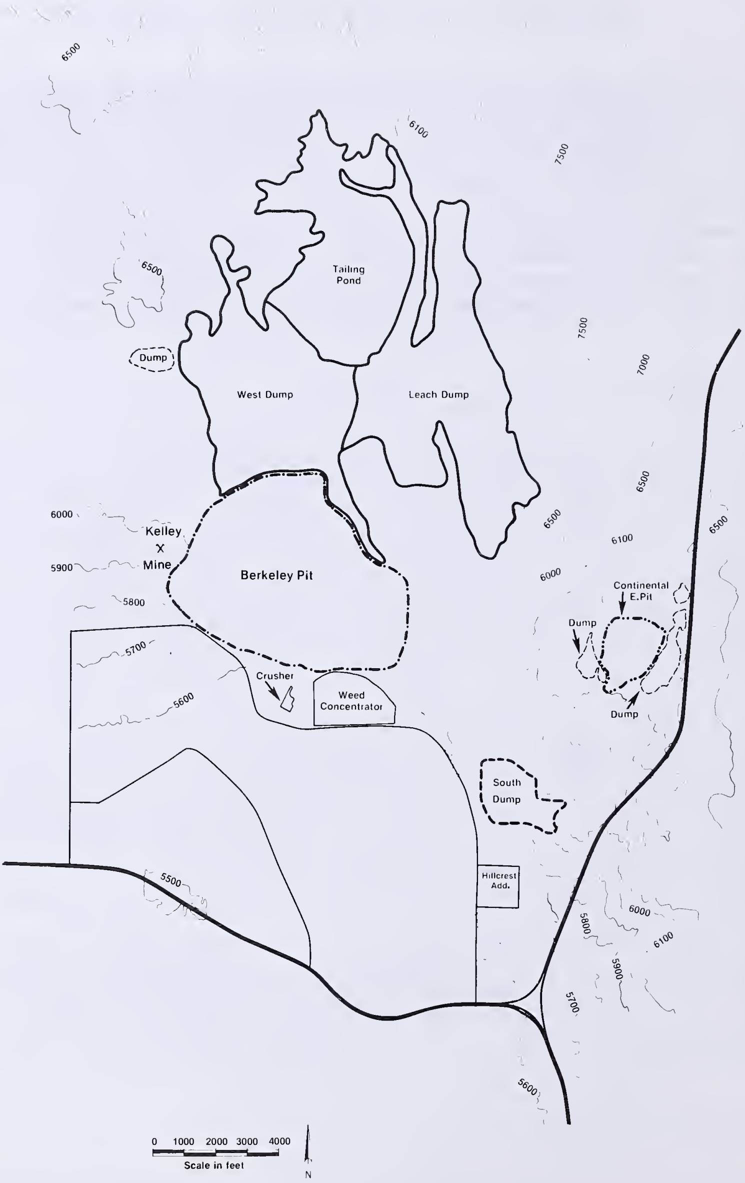


FIGURE I-1.--General location map of mine areas and facilities of the Anaconda Copper Company in Butte, Montana. Contour interval: 100' to 6100' elevation; 500' thereafter.

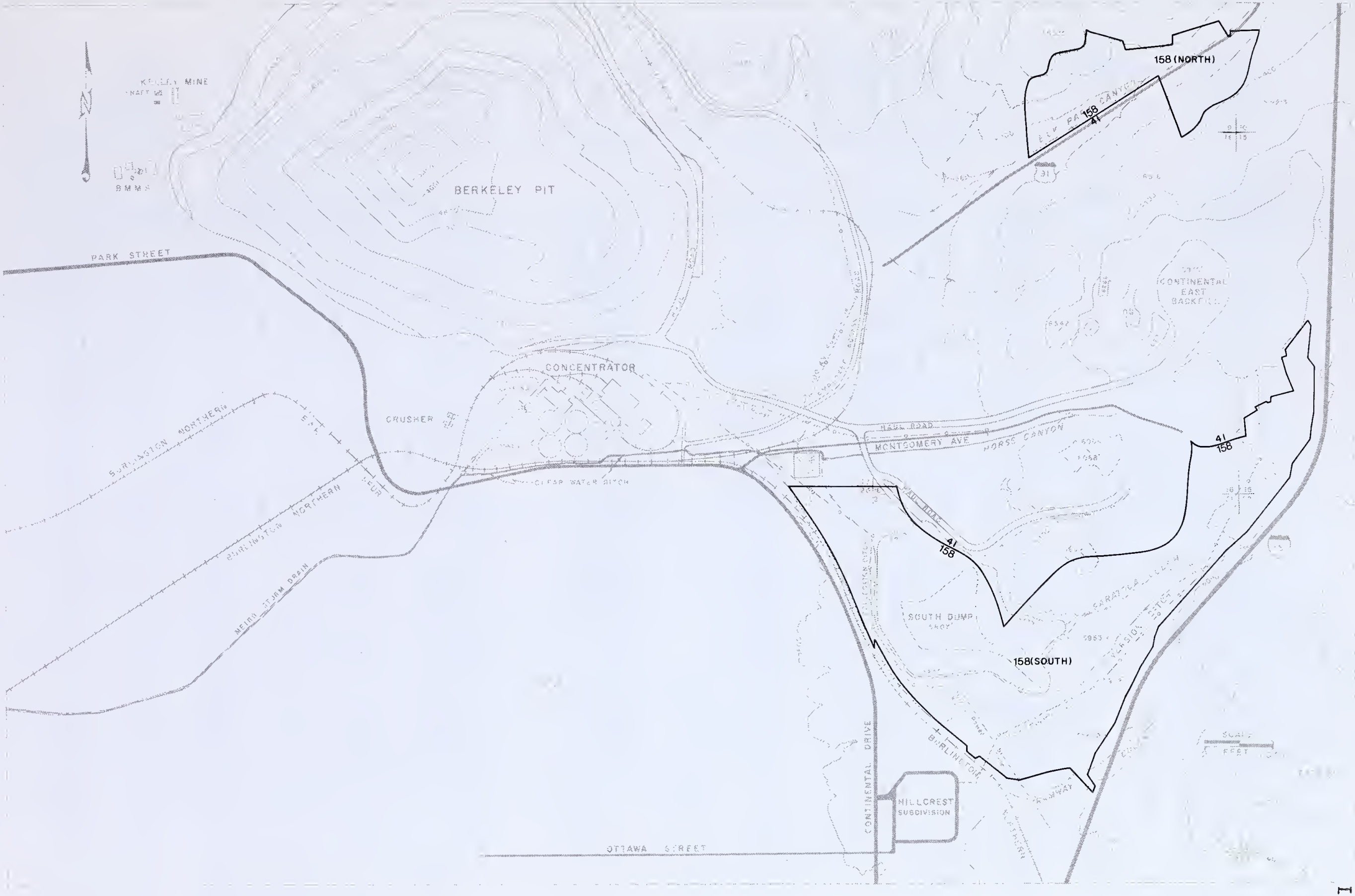


FIGURE I-2.--Boundaries of permit application area no. 158.

The Department's rules adopted pursuant to the Montana Environmental Policy Act require the assessment of cumulative impacts from the application. Cumulative impacts that would result from approval of the permit are discussed in chapter III and include:

- Physical changes on the 428 acres of the permit area.

- Physical changes in surrounding areas due to the dumps, such as in air and water quality.

- Physical changes due to mining, processing, and transporting ore, waste rock, and tailings associated with use of the permit area.

- Social and economic impacts from Anaconda's entire Butte operations. Because the proposed dump areas makes possible the expansion of the Berkeley Pit, employment changes and the resulting fiscal and social impacts cannot be attributed to either the pit or the waste dumps--both operations are interdependent. The south dump would also have direct social impacts as a result of its construction and appearance.

- Physical, social, and economic impacts that would result from alternatives to approval of the proposed permit.

C. MINING PLAN

The following description of Anaconda's current and proposed operations is based on information in the company's permit application and in Montana Copper, a brochure prepared by the company in 1979.

1. General Operations

Three kinds of material--copper ore, leach rock, and waste rock--have been mined from the Berkeley pit. Ore, which averages 0.5 percent copper, is trucked to a crusher south of the pit. The crushed ore is sent by conveyor belt to the Weed Concentrator where it is further ground and concentrated in a flotation process. Tailings left over from the flotation process are piped to a large pond north of the pit. The concentrated slurry (26 percent copper) had been shipped by railway tank cars to a smelter in Anaconda, 26 miles west of Butte; however, on September 29, 1980, Anaconda announced the closure of its smelter and its refinery in Great Falls. At that time Anaconda workers were on strike and no concentrate was being produced; after the stike ended, the company began shipping concentrate to Japan for smelting.

In addition to copper, considerable amounts of gold and silver are also produced from Anaconda's Butte operations (table I-1). The company expects to produce an average of about 82,400 tons of copper/year (see chapter III, Economics). The company is currently developing underground mining to determine the economic feasibility of future block caving operations at Butte. Block caving is a method of underground

TABLE I-1.--Selected minerals production summary, Montana total and Anaconda Company, 1961-79

[Source: Montana Department of Revenue, Miscellaneous Tax Division, unpublished report forms--statement of gross yield of mines and metalliferous mines' license tax]

	Copper (short tons)			Gold (troy ounces)			Silver (troy ounces)		
	Montana	Anaconda	Percent	Montana	Anaconda	Percent	Montana	Anaconda	Percent
1961	102,142	102,105	100.0	29,915	18,158	60.7	3,158,014	2,798,482	88.6
1962	91,940	91,920	100.0	17,244	16,638	96.5	3,966,582	3,762,076	94.8
1963	80,085	80,082	100.0	13,787	13,674	99.2	3,781,250	3,745,452	99.1
1964	101,038	101,025	100.0	20,715	20,291	98.0	4,728,327	4,510,474	95.4
1965	117,481	117,476	100.0	19,181	18,712	97.6	4,736,114	4,706,132	99.4
1966	121,793	121,791	100.0	20,767	20,345	98.0	4,730,696	4,697,204	99.3
1967	63,387	63,385	100.0	8,238	8,222	99.8	2,016,520	1,897,375	94.1
1968	69,061	69,061	100.0	10,853	10,839	99.9	1,890,764	1,726,749	91.3
1969	105,281	105,279	100.0	16,246	15,940	98.1	2,681,867	2,583,439	96.3
1970	118,196	118,196	100.0	21,060	20,067	95.3	3,669,855	3,533,000	96.3
1971	88,599	88,599	100.0	15,810	15,133	95.7	2,716,070	2,600,780	95.8
1972	125,607	125,607	100.0	22,660	22,196	98.0	3,235,829	3,090,932	95.5
1973	127,749	127,749	100.0	22,397	20,827	93.0	3,959,641	3,741,617	94.5
1974	132,324	132,324	100.0	25,846	23,935	92.6	3,517,767	3,287,710	93.5
1975	94,145	94,144	100.0	18,541	13,758	74.2	2,601,411	2,179,250	83.8
1976	101,784	101,684	99.9	23,350	21,756	93.2	3,026,402	2,731,754	90.3
1977	83,865	83,716	99.8	21,023	20,626	98.1	2,948,049	2,729,836	92.6
1978	76,533	76,024	99.3	16,437	15,107	91.9	2,588,231	2,072,715	80.1
1979	80,805	80,164	99.2	24,198	21,129	87.3	2,981,501	2,563,909	86.0

mining that extracts large volumes of ore and is considered to be one of the lowest cost underground mining methods (U.S. Department of Commerce, 1974). If the underground block caving operation is undertaken, average annual copper production would be about 112,000 tons.

Leach rock was formerly hauled to dump pads north and east of the pit (fig. I-1). A sulfuric acid solution was used to leach out copper from the existing leach dumps. Currently there is no distinction between leach and waste material. Waste is dumped north of the Berkeley pit, in pit backfill, or in the Continental East area.

Figure I-2 shows operations as of January 1, 1980. Mining is confined to the present Berkeley Pit. The Continental East Pit is backfilled to the 5975 foot elevation and the south dump has reached the 5800 foot elevation (175 feet above its base). Because use of the proposed permit area is prohibited until a valid permit is issued, the area is not included in the mining plans during the first half of 1981.

Utilities consisting of a storm water runoff diversion system, a 12.5 kV power line serving Elk Park and X-L Heights, a telephone line serving the same areas, and a 100 kV power line serving the mine and concentrator occupy space in the south portion of the proposed permit area. Numerous exploration sites, roads, and a waste dump also are present in the area.

2. Planned Pit and Dump Operations

a. General

The proposed permit would allow Anaconda to resume hauling waste rock to the south dump and begin use of the north dump in Elk Park Canyon (fig. I-2). These two areas comprise 428 acres. Continued development of the Berkeley Pit would eventually intersect a small part of the south dump application area; waste rock would be removed from that area as part of the expanded pit. Waste rock would be produced from three areas: the Southeast Berkeley Pit, a haul trench from the main Berkeley pit to the south dump, and from the Berkeley Pit and its expansion.

b. End of year 1

Figure I-3 shows operational changes at the end of year 1. The Southeast Berkeley Pit would be mined by conventional truck-shovel methods. Waste would be dumped immediately east of the Southeast Berkeley Pit and north of Montgomery Avenue in the first half of year 1. Subject to current litigation and closing of public streets, Montgomery Avenue would be dumped over and the south dump would receive waste from the Southeast Berkeley Pit. The mining of a haul trench east of the Berkeley Pit would contribute waste to Continental East Pit backfill. By the end of year 1, the dump elevations would reach 5950 feet east of the Southeast Berkeley Pit, and 5850 feet (225 feet above base) in the south dump.

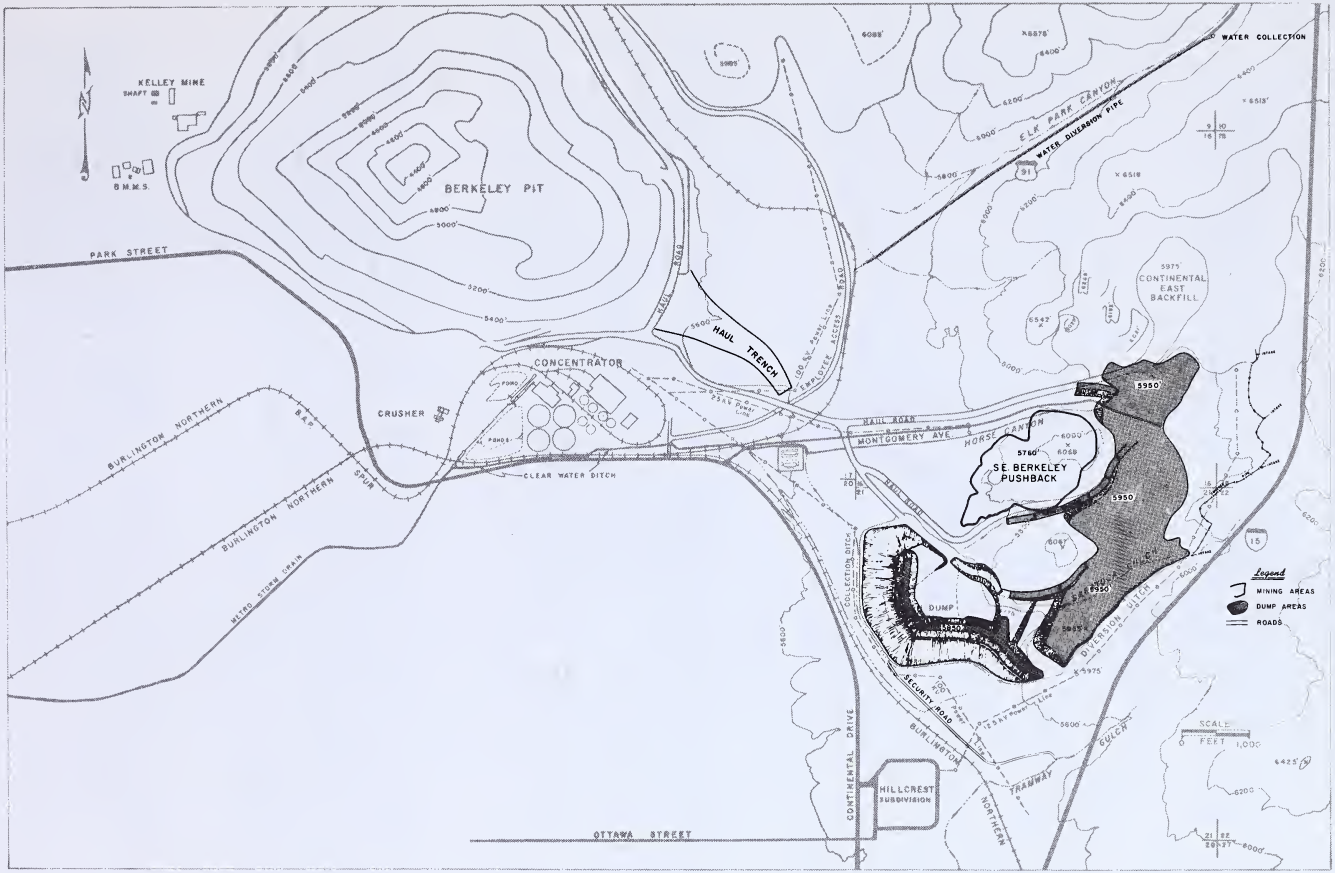


FIGURE I-3.--Operational changes at the end of year 1 of the mine plan.

A security road would be established along the fence line in the southern portion of the proposed permit area. The purpose of the fence and road is to improve safety by closing operational areas to the public.

c. End of year 3

Figure I-4 shows operational changes at the end of year 3. The Southeast Berkeley Pit would be completed and backfilled. The south dump would be expanded to the east and northeast and joined to the Continental East Pit backfill dump. Alluvium in the first East Berkeley pushback (expansion of the mine pit) would be mined and transported by conveyor to the south dump where it would be spread by a shiftable conveyor and stacker and then graded to the planned profiles (fig. I-5). The alluvium would be dumped over the top of the waste rock, serving as a more favorable medium for plant growth. Topsoil would be placed on top of the alluvium in critical areas such as south- and west-facing slopes. Cross-sections A-A' and B-B' (fig. I-6) show the planned south dump profile. All dump slopes would be 24° or less.

d. End of year 6

By the end of year 6, the south dump would be completed to the 6100 foot elevation (375 feet above base) with alluvium and waste rock from the first and second East Berkeley pushbacks. The conveyor system would be relocated to the East Berkeley #2 pushback and also to the southwest end of the south dump. The 12.5 kV power and telephone lines would be relocated to their final positions, and the final addition to the runoff diversion system would be made. All mining-related activities along the east permit boundary would not interfere with the future expansion of Interstate I-15. The east permit boundary is the proposed west right-of-way line of the new I-15.

e. End of year 7

Figure I-7 shows operational changes at the end of year 7. Waste rock and alluvium would be stripped from the upper benches of pushbacks 3 and 4. Mining in the east and northeast area would contribute waste rock to the north dump in Elk Park Canyon which would have a final elevation of 6300 feet (450 feet above base at its lower end). Alluvium and some rock from the lower benches would be transported by conveyor to backfill the west part of the Berkeley Pit.

f. End of year 10

Figure I-8 shows the operational changes at the end of year 10. The fifth East Berkeley pushback would be stripped, and utilities relocated to the south and east sides of the mine plan. The utilites in the south area of the plan would be: 100 kV power line, contaminated-water disposal ditch, employee access road, gas line, sewer line, telephone line, tailings lines, tailings spill ditch, and the return water line.

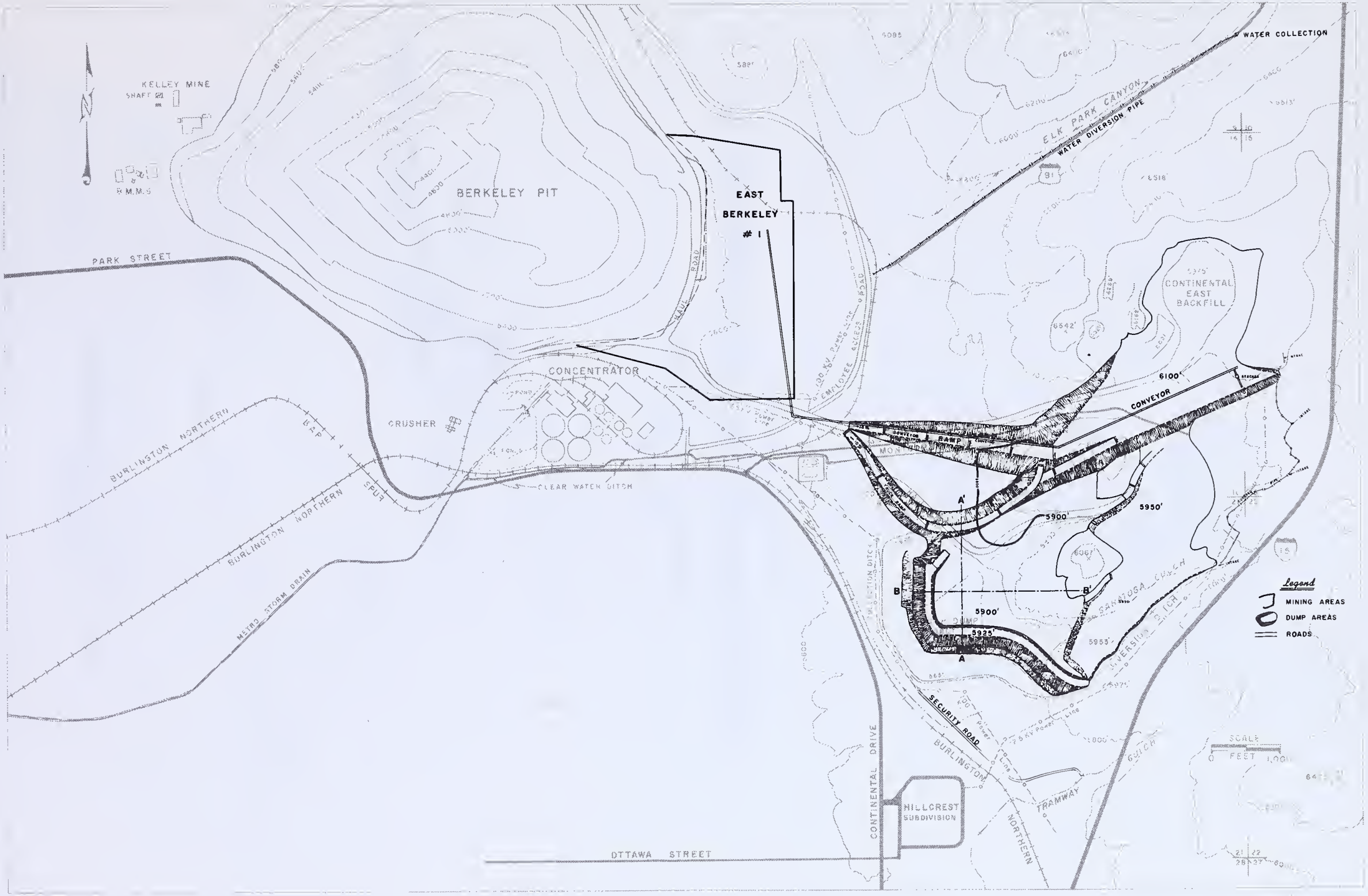
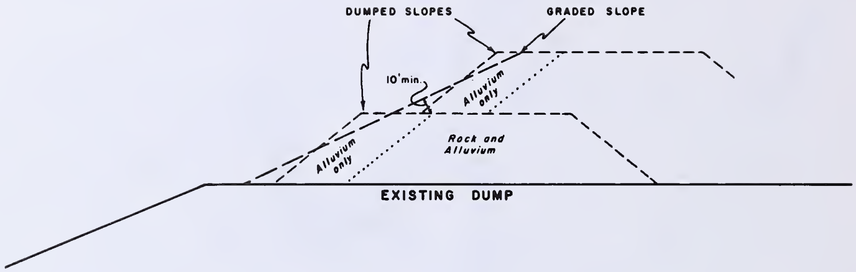
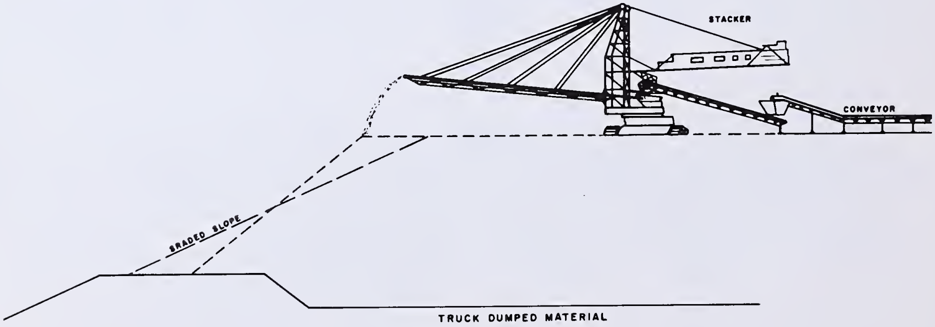


FIGURE I-4.--Operational changes at the end of year 3 of the mine plan.

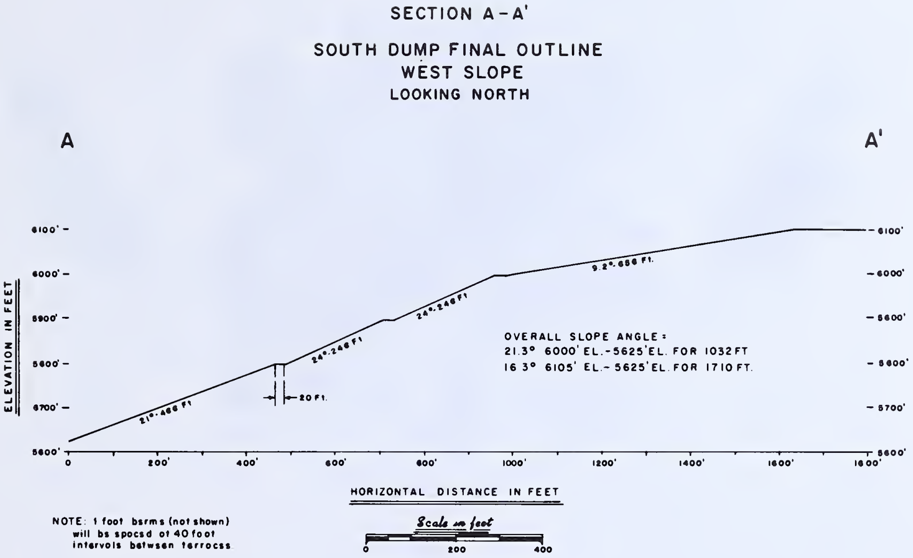


CONSTRUCTION of SOUTH DUMP PERIMETER
With
SHOVEL-TRUCK OPERATION
SCHEMATIC



SOUTH DUMP STACKING OPERATION
SCHEMATIC

FIGURE I-5.--Construction of the south dump perimeter, planned profile and stacking operation.



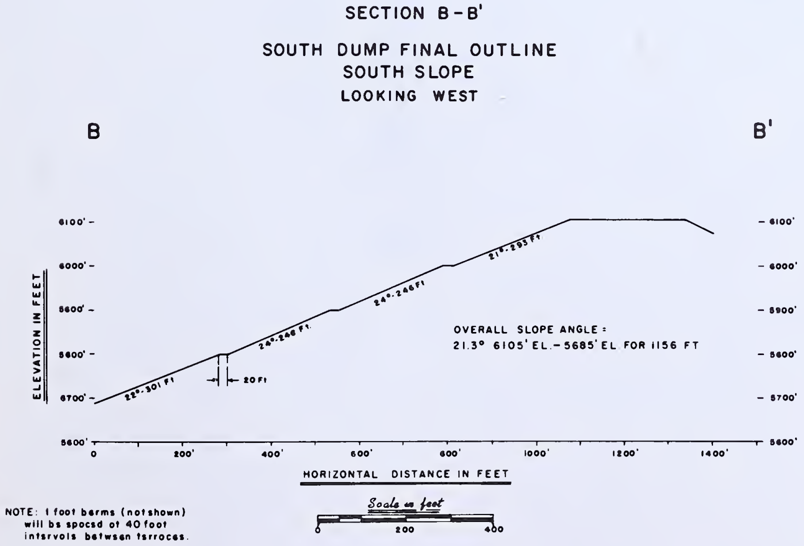


FIGURE I-6.--Planned south dump profiles. Location of cross-sections is shown in fig. I-4.

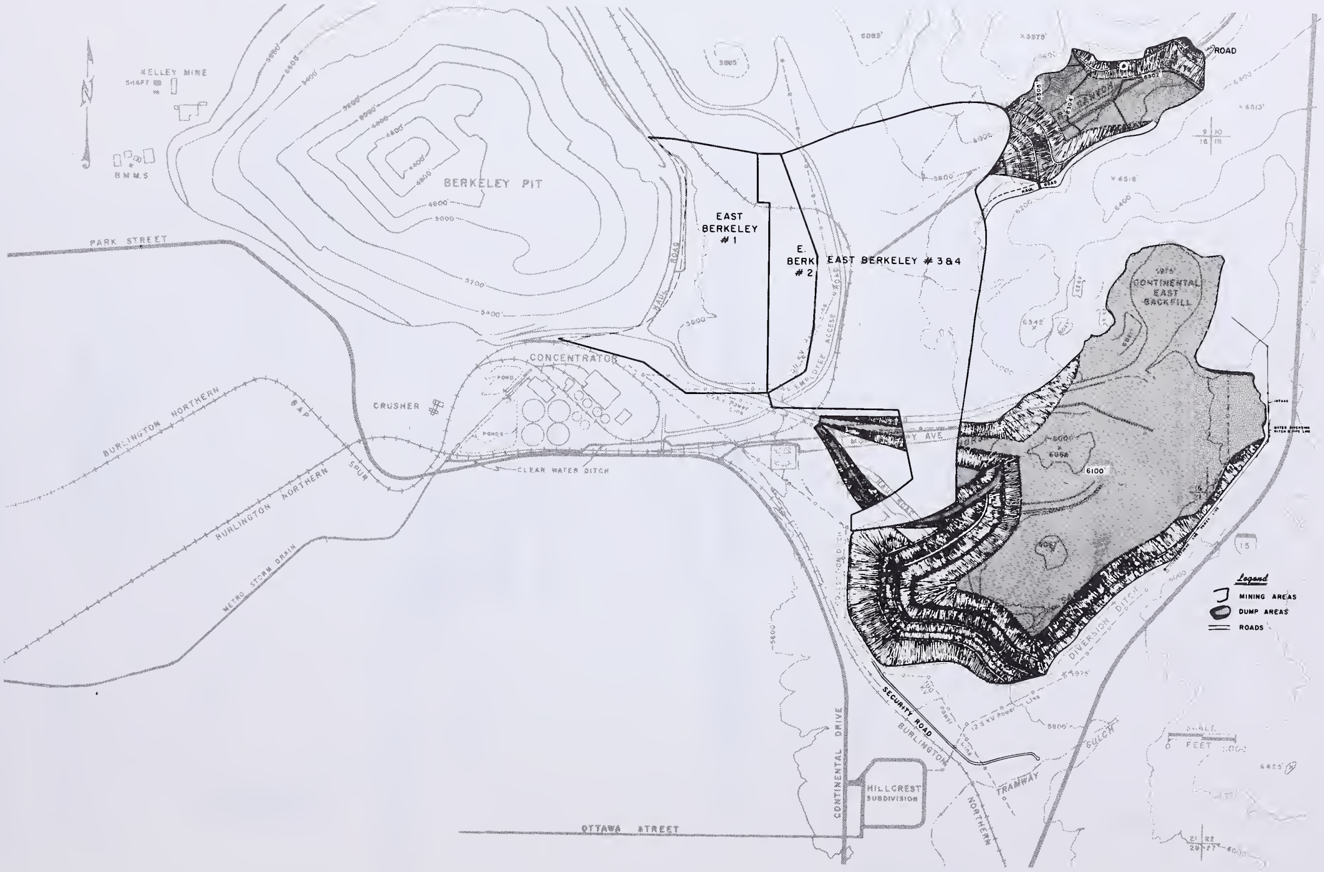


FIGURE I-7.--Operational changes at the end of year 7 of the mine plan.

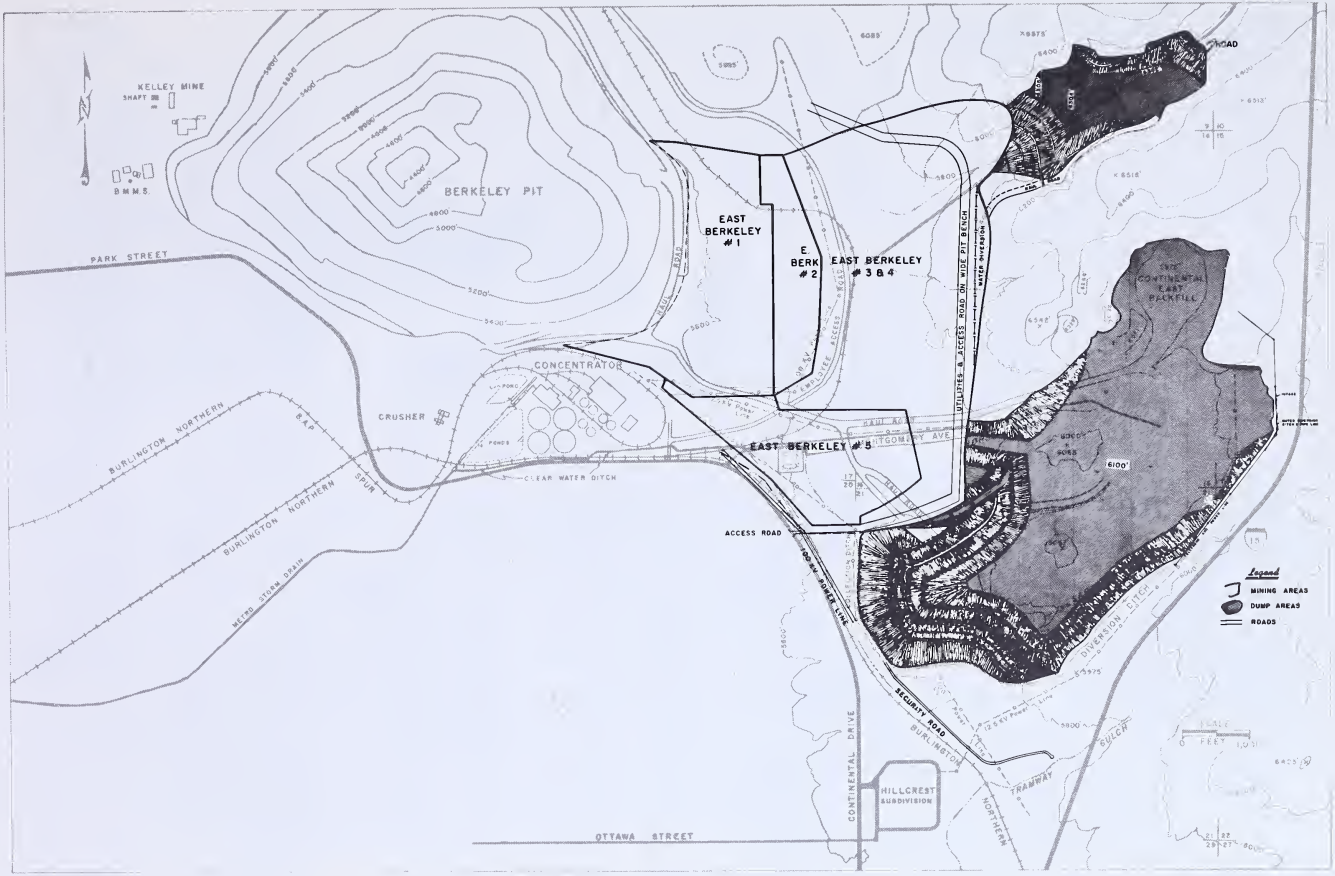


FIGURE I-8.--Operational changes at the end of year 10 of the mine plan.

The Montana Power Company's 100 kV power line would cross the permit area. This line services the concentrator and crusher, and would service the new pit substation. The contaminated-water disposal ditch would collect waste dump runoff and carry it to the concentrator tailings disposal system for treatment. Both the power line and the water ditch are presently in the permit application area and would be partially relocated. The tailings pipelines would carry about 50,000 tons/day of concentrator tailings north to the tailings pond. A ditch would be parallel to the pipelines and would carry any spillage from pipeline leaks back to the concentrator tailings circuit. The return water pipeline would be a 36-inch pipe returning 25,000 gpm of clear water to the concentrator from the tailings pond after tailings have settled out. This water is used again for concentrator process water and for pumping tailings up to the pond.

g. Abandonment

When dumping is completed in the permit area, the conveyor-stacker system would be removed. Haul roads and access roads not needed for continued maintenance of reclaimed areas would be treated as described in the reclamation plan. Security fencing and associated patrol roads would remain, as would utilities serving continued mine-mill operations in adjacent areas.

D. SUMMARY OF RECLAMATION PLAN

Additional detailed information about Anaconda's proposed reclamation plan for application area no. 158 is contained in the company's permit application which is on file with the Department of State Lands.

Anaconda proposes to reclaim the permit area to provide watershed protection and small mammal and bird habitat. Nineteen acres of the permit area would be within the outermost extent of the expanded Berkeley Pit; the final use of the pit would be waste water containment and treatment. Figure I-9 shows the final configuration of the dumps and the pit.

1. Erosion Control Plan

The company proposes to construct the two waste rock dumps with three 20-foot-wide terraces to control runoff (fig. I-6). The terraces would be sloped into the dump at about 6 degrees (10 percent) and would carry runoff laterally off the dump faces to the water diversion system. The company would also construct 1-foot-deep horizontal berms every 40 feet to capture runoff and allow it to infiltrate into the dump.

The company would maintain the terraces and berms until the planted vegetation is well established; at which time the terraces and berms would be partially filled and sloped away from the dump at about 3 degrees (5 percent). Maintenance would include repairing any gullies and localized vegetative failures.

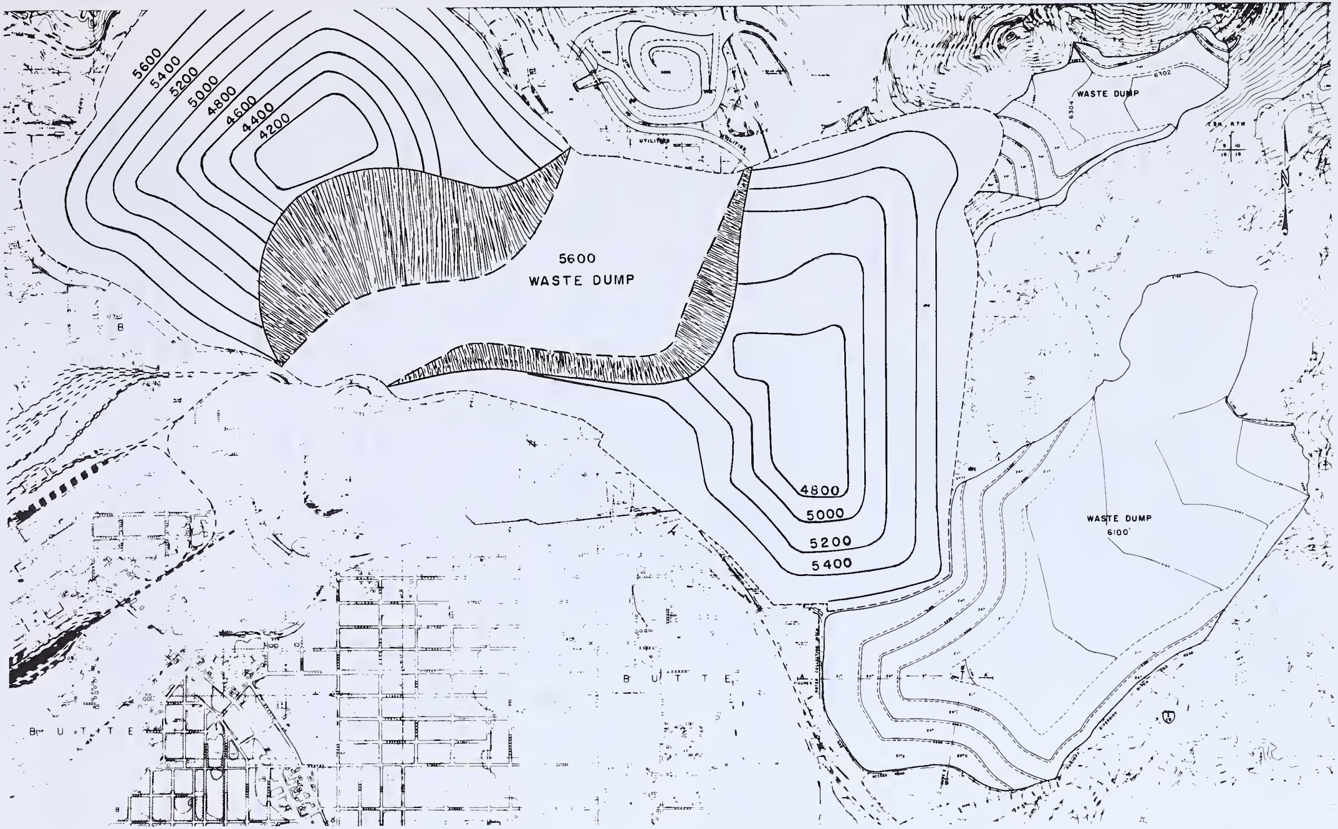


FIGURE I-9.--Approximate final configuration of the dumps and the pit.

2. Soils and Vegetation

Where practicable, all available undisturbed surface soil would be stripped and stockpiled prior to disturbing an area. Handling of the topsoil would be kept to a minimum. Where possible, it would be stripped just prior to disturbing an area and deposited in a location where it can remain until it is used to veneer final dump slopes and tops. In certain situations, operational considerations and equipment availability may necessitate interim storage in a temporary stockpile.

All stockpiles would be graded and planted with a mixture of grasses and legumes to prevent wind and water erosion, discourage the growth of undesirable plant species, and increase the amount of organic matter in the soil. The soil would be used as a surface veneer on a portion of the final dump tops and slopes. Because the surface soil would not sufficiently cover all the areas to be reclaimed, alluvial overburden would also be used as a surface veneer (see chapter III, Soils and Alluvium). Soil would be reserved for use on final dump top surfaces or critical areas such as south-facing slopes.

On dump tops and slopes where standard agricultural tilling and planting equipment can be used, fertilizer, lime, and organic matter would be applied, if research determines it necessary. A field cultivator would then be used to incorporate the fertilizer, lime, and organic matter into the alluvium or soil and to loosen surface compaction. A seedbed would then be prepared with a harrow and the area planted with a grass-legume mixture. Following planting, all slopes would be mulched with straw to help control erosion. Slopes too steep to permit the use of machinery, such as road berms and similar small areas, would be limed, fertilized, seeded, and mulched with a hydroseeder.

All planting would be done in late fall or early spring. If after two growing seasons the grass-legume mixture is successfully established, shrub and/or tree seedlings would be planted on some areas. The plant species used in reclamation would be predominantly native (see table III-4). Most of the tree and shrub seedlings would be grown from seed in a company greenhouse. Part of the seed would be collected locally; the remainder would be from an area of comparable climate and altitude.

Refertilization of planted areas may be necessary until levels of soil organic matter are adequate. If initial revegetation is unsuccessful, the company would seek the advice of the Department of State Lands before replanting.

The reclamation plan proposed by the company states that the final vegetation establishment on the dump slopes would be of similar cover density as the vegetation found on typical natural slopes in the area having similar steepness, aspect and type of vegetation. The plan additionally states that erosion rates on the dump slopes would be of similar magnitude as erosion rates on typical natural slopes in the area having similar steepness and aspect.

If, at the time of the company's request for bond release, the Department of State Lands estimates that the vegetative cover and erosion rate standards could not be met, the Department would then withhold bond release.

3. Hydrology

The permanent runoff diversion system and all water control structures within the permit area would be designed to withstand a 100-year flood. Water within the disturbed area would be collected and treated until all work within the Berkeley Complex is halted. Upon abandonment of the Berkeley Pit, all contaminated water, including that flowing from the permit area, would be diverted to the pit. The company expects new treatment technology to be available by the time the mine is abandoned, and as a result, has not proposed a method of treating any surface or ground water leaving the pit.

Ephemeral streams that now flow through the proposed south dump area would be diverted by pipes and ditches around the south edge of the dump. Initially, this water would enter a settling pond and be released to a clearwater ditch which enters Silver Bow Creek. The settling pond would eventually be mined out as the pit expanded to the southeast; the diverted water would then be directed to the concentrator tailings-disposal circuit. Runoff from the top of the south dump would be directed to the clearwater ditch and on to Silver Bow Creek.

Elk Park Canyon Creek would be carried by a pipe under the proposed north dump and into the clearwater ditch. Runoff from the top of the north dump would also be directed to the clearwater ditch.

During mining, all water released to Silver Bow Creek would have to meet the requirements of Anaconda's MPDES discharge permit (MT-0000183). If the runoff did not meet the permit requirements, additional treatment such as a settling pond would be necessary.

Erosion on access and haul roads would be controlled by ditches, berms, and culverts. When mining is completed, haul roads would be graded to blend with the surrounding land, veneered with soil or alluvium, and planted. Access roads that must remain open after mining would be constructed at a relatively low gradient using such water control measures necessary to prevent erosion. Roads used infrequently would be planted with a grass-legume mixture.

4. Air Quality

If it is necessary to stabilize exposed areas prior to their revegetation to prevent wind erosion, a nontoxic dust retardant or water would be applied, or other measures taken. Roads will be watered to reduce fugitive dust.

5. Dump Monitoring Program

The Anaconda Company proposes to initiate a dump monitoring program. The monitoring of the dumps' vegetation and erosion could lead to appropriate changes in reclamation techniques or even slope angles, if necessary. Anaconda's dump monitoring program would consist of the following:

a. Vegetative canopy coverage and ground coverage (everything but bare soil) will be monitored on the dumps using accepted, standard range and analysis methods. Monitoring will occur on an annual basis and results will be made available for the Department's review in Anaconda's Butte offices and may be included in its annual report.

b. Utilizing a statistically valid sampling method, including photographs, Anaconda Company will annually monitor erosion rates on each major dump aspect and on each lift. Erosion monitoring results will be made available for the Department's review in Anaconda's Butte offices and may be included in its annual report.

c. In order to provide a basis for comparison, Anaconda shall also conduct a monitoring program as described for a. and b. above on similar natural slopes in the area.

d. Before commencing a revegetation and erosion monitoring program, Anaconda will seek the advice of the Department.

CHAPTER II

DESCRIPTION OF THE EXISTING ENVIRONMENT

A. TOPOGRAPHY AND GEOMORPHOLOGY

1. Upper Silver Bow Basin

Upper Silver Bow Creek drains a basin about 10 miles wide and 22 miles long on the west slope of the Continental Divide (Botz, 1969, p. 4). Blacktail Creek drains the south part of the basin and joins Silver Bow Creek which drains the north part of the basin on the western margin of Butte.

The basin is bounded on the east by a steep, rugged bedrock ridge, locally known as East Ridge. East Ridge exceeds 8000 feet elevation in several places and is slightly-to-moderately dissected by numerous small streams (Botz, 1969, p. 4). The northern, southern, and part of the western borders of the basin are also mountainous with altitudes that range from 6,000 to over 8,000 feet. The altitude of the Silver Bow basin floor ranges from about 5,620 feet at the southern end and drops to about 5,400 feet where it leaves the valley between the communities of Rocker and Butte.

The central portion of the basin, including part of the proposed permit area, is filled with alluvium derived from weathering and erosion of the granitic Boulder batholith. (see chapter II, Geology).

Sediment erosion rates in the Silver Bow basin have not been specifically measured. The U.S. Soil Conservation Service conducted studies of erosion based on visual observations at 4-5 sites around Butte, none of which showed evidence of excessive erosion (i.e., mixing of the A and B soil horizons or vegetative pedestaling). Based on this limited study, excessive erosion is probably not widespread in the basin. However, much of the natural landscape has been disturbed by human activity particularly in the Butte area. Such areas probably have relatively high rates of sediment erosion because they lack vegetation.

2. Dump Areas

The landscape within and adjacent to the proposed waste dumps is hilly to mountainous. The dumps would be located across several small drainages (see Hydrology).

Elk Park Canyon, the site of the proposed north waste dump, is a canyon cut through granitic bedrock. The elevation of the bottom of the canyon where the dump would be located ranges from 6,100 feet at the upstream end to about 5,800 feet at the mouth of the canyon. The hills on both sides rise steeply to over 6,500 feet (see fig. II-1).

Two small hills rise to an elevation of just under 6,100 feet within the proposed south dump site. Three small intermittent streams flow through the south dump site.

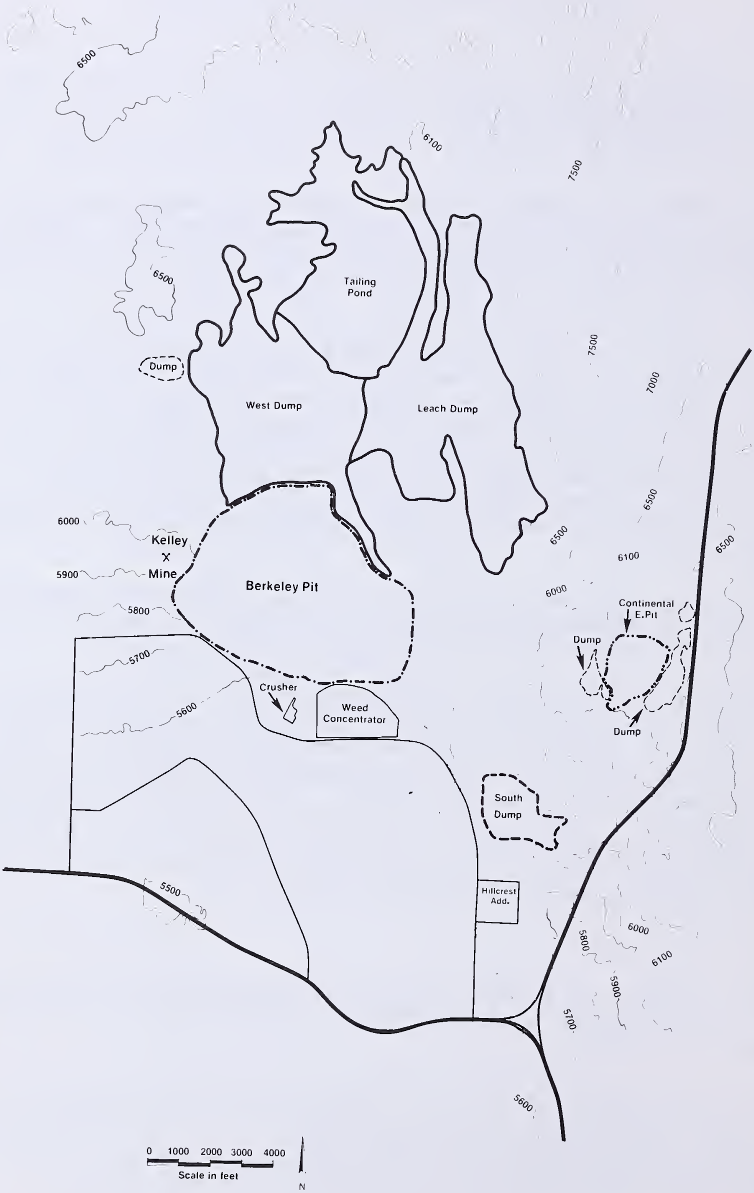


FIGURE II-1.--Topographic map showing Anconda's existing Berkeley mine. Contour interval is 100 feet up to 6,100 feet; with 500 foot contours above 6,500 feet due to steep terrain.

The proposed site of the south dump has been disturbed by mining during the last 100 years. Anaconda recently completed mining of the Continental East Pit (fig. II-1), and has partially backfilled it with waste rock. Other smaller disturbances exist on the bedrock hills within the limits of the proposed south dump. Most of these disturbed areas have little vegetation. The surface of the ground of these disturbed areas is covered with a thick coating of pebbles which helps control erosion.

Anaconda began dumping waste rock from the Berkeley Pit at the south dump location in 1976. The south dump grew to about 175 feet above its base near Continental Drive before work was stopped by court order in 1979 (see chapter I). The dump was constructed in three terraces and graded to 32°. The dump's west face was covered with alluvium, a thin layer of topsoil and then revegetated. Some of the west face is now densely vegetated; however, some areas are sparsely vegetated and have erosion problems. A few large gullies have formed where runoff water was concentrated by roads on the terraces.

The south face of the existing dump was regraded to 24°, partially covered with alluvium, but never revegetated due to the court injunction. Even though the waste rock has not been revegetated, very little erosion has occurred on it. The reason for this is that the waste rock is coarse textured and has a tendency to form a protective crust. A portion of the regraded south face of the south dump was covered with 3-4 feet of alluvium. The bare alluvium has been severely eroded in places by runoff. The runoff waters came from the top of the dump and from runoff collected on the dump face itself. Closely-spaced rills and several 4'-6' deep gullies have developed in the alluvium.

Sheet and rill erosion rates on the alluvium are estimated to be 150-200 tons/acre/year, based on the Universal Soil Loss Equation (U.S. Soil Conservation Service and U.S. Environmental Protection Agency, 1977). This does not include gully erosion, which substantially increases the total erosion rate. Most of the coarser sediment has been deposited at the base of the dump, completely covering existing vegetation. Based upon visual observations the finer sediment is suspected to have reached Silver Bow Creek via a diversion ditch.

Visually the high rates of erosion and the formation of deep rills and gullies show how erosive the alluvium is, although the present situation is an extreme example. The Anaconda Company has been prohibited from vegetating the south dump. Since vegetation is so important in controling erosion, the amount of erosion is probably at least 10 fold greater than if the slopes had been revegetation.

B. SOILS

The soils in the proposed permit area, like all soils in the upper Clark Fork river basin, vary dramatically in their physical and chemical properties owing to their degree of development (age), the complex geological history of the area, and diverse climatic and vegetative conditions (Casne and others, 1975).

Soils in the proposed permit area have recently been mapped, sampled, and described by Rudio and Associates (1980) in accordance with the system used by the U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS). The short names given to the soil series (table II-1) are unofficial and are subject to change as the official SCS soil survey progresses in Silver Bow County.

TABLE II-1.--Soil resources of proposed permit area 158

Soil Series*	Proposed Acreage To Be Disturbed	Proposed Salvage Depth (inches)	Proposed Soil Salvage Volume (acre-feet)
App	3.3[a]	10	2.8
Koy	22.0	25	45.8
Nib	19.7	60	98.5
Tet	38.0	6	19.0
Totals	83.0[b]		166.1

*Soil Series names are not official names designated by the Soil Conservation Service. They are for reference purposes only.

[a] Roughly 5.8 acres of the "App" series will actually be disturbed; however, only 3.3 acres can be salvaged due to the wetness of the area and machinery limitations.

[b] This acreage figure does not include soils that are located on slopes too steep for salvage operations, disturbed areas, existing mine waste areas, and areas within the proposed permit area that will not be disturbed during dump construction.

Capability groupings (U.S. Department of Agriculture, Soil Conservation Service, 1971) range from class IV, VI and VII in the proposed permit area to class VIII on the surrounding steep mountainsides. The class IV soils are marginally suitable for cultivation and have severe management limitations; the class VIII soils are suitable only for recreation, wildlife, water supply, and esthetic purposes.

Soil resources of proposed permit area 158 are limited in volume (table II-1). The Anaconda Company is proposing to salvage approximately 166 acre-feet of soil material from the area that would be disturbed during construction of the dumps within the proposed permit area boundary.

Although 8 different soils plus 2 disturbed soil types were mapped within the proposed permit area, only the 4 soils listed in table II-1 would be salvaged. The remaining soils are on slopes too steep for salvage operations, are too shallow or wet, or would not be disturbed during dump construction. Anaconda also proposes to use soil material from existing permit areas for dump reclamation as these areas are disturbed by the Berkeley Pit expansion to the east. However, soils from the former McQueen neighborhood (part of permit area 30A) would not be suitable for salvage because of potentially toxic metal concentrations, an array of streets, utility pipes, and other physical restrictions to soil salvage, and a lack of surface soil horizons containing organic matter.

The most desirable soils proposed for use on the waste dumps are those being salvaged from the Columbia Gardens area which is being disturbed by the construction of a waste dump in permit area 41. These soils have a volume of about 35 acre-feet and appear to have desirable texture and a thick, organic-rich surface horizon.

Anaconda would also salvage soils from other areas that would be disturbed as the Berkeley Pit expanded to the east, including small fields that are relatively undisturbed and accessible to salvage. Areas such as these would not contribute significantly to the overall soil volume necessary for dump reclamation.

Since suitable soil volumes in the proposed permit area and surrounding areas are not sufficient as a vegetative growth medium on dump surfaces, alluvium would also be used. The reclamation potential of this material is discussed in chapter III, Vegetative Reclamation; its origin is described in chapter II, Geology.

C. VEGETATION

The proposed permit area contains a variety of native range and woodland vegetation as well as plant communities that have been dramatically altered by past mining, logging, grazing, and smelting operations. Approximately 23 percent of the proposed permit area is disturbed and is essentially barren of vegetation except for invading forbs and annual grasses.

Vegetation in the proposed permit area has been mapped by the Montana Department of Natural Resources and Conservation (1974), Siemans (1975), and Ross and Hunter (1976). In addition, a quantitative vegetation analysis of the area was conducted by WESTECH (1977). The most recent vegetation inventory (ECON, INC., 1980), delineated five plant community types.

The rubber rabbitbrush/grassland type is the most common plant community in the permit area (30 percent of total area). It occurs on all aspects at various slopes. Rubber rabbitbrush (Chrysothamnus nauseosus) is the dominant shrub in this type and visually dominates the area, although canopy coverage did not exceed 15 percent in any of the transects. Dominant grasses in this type include bluegrass (Poa spp.), slender wheatgrass (Agropyron trachycaulum), tufted hairgrass (Deschampsia caespitosa), and rough bentgrass (Agrostis scabra).

The grassland type occurs over approximately 23 percent of the area on various slopes and aspects; however, the stands were usually small (less than 10 acres). Two distinct phases of this type were identified: one dominated by bluebunch wheatgrass (Agropyron spicatum) with widely scattered rubber rabbitbrush, the other dominated by bluegrass and rough bentgrass.

The aspen woodland type is found on northerly aspects and in draws at lower elevations, and on all aspects at upper elevations. This type occurs on approximately 20 percent of the permit area. Quaking aspen (Populus tremuloides) dominates the overstory, forming even and uneven stands of saplings and mature trees. The aspen has apparently inhibited invasion by other tree species; however, lodgepole pine (Pinus contorta), Douglas-fir (Pseudotsuga menziesii), and Rocky Mountain juniper (Juniperus scopulorum) are occasionally found interspersed with the aspen. Common understory shrubs include white spiraea (Spiraea betulifolia), rose (Rosa spp.), gooseberry (Ribes setosum), Oregon grape (Berberis repens), chokecherry (Prunus virginiana), buffaloberry (Sheperdia canadensis), common juniper (Juniperus communis), and kinnikinnick (Arctostaphylos uva-ursi). The most common grass associated with this type is bluegrass.

The lodgepole pine type and willow bottom type occur much less frequently, occupying approximately 2 percent and 1 percent of the permit area, respectively. The lodgepole pine type is similar to the aspen woodland type except that lodgepole pine is dominant in the overstory. This type occurs on moist north and northwest facing aspects on the southeast side of Woodville Gulch. In addition to lodgepole pine and aspen, Douglas-fir, whitebark pine (Pinus albicaulis), and Rocky Mountain juniper are occasionally present. Common understory shrubs are similar to the aspen woodland type with the addition of willow (Salix spp.), dogwood (Cornus stolonifera), and currant (Ribes spp.). The oldest trees in this type are roughly 50-56 years old.

The willow bottom type is found adjacent to drainages throughout the permit area. This type has a thick tree and shrub overstory and a forb/grass understory. Dominants in the overstory are willow, rose, and aspen. Bluegrass and rough bentgrass are found in a few places in the understory.

Range conditions and stocking rates have been estimated for two community types. For the rubber rabbitbrush/grassland type, the range condition is poor and has a stocking rate of 0.1 animal-unit-month (AUM)/acre. The forest type (aspen or lodgepole communities) is in fair condition, and has an estimated stocking rate of 0.1 AUM/acre (ECON, 1980).

Plant species lists, canopy coverage data, frequency data, and standing crop data are available for the proposed permit area from the Montana Department of State Lands in Helena.

D. WILDLIFE

The following discussion is derived from reconnaissance-level work by Western Technology and Engineering, Inc. (WESTECH) during 1976-77 and again in 1980 (Rudio and Associates, 1980). The study area consisted of proposed permit area 158 (both the north and south units) and northward to the Yankee Doodle Creek drainage. The study area was visited on 26 days between January, 1976 and September, 1980. Actual population levels and species occurrence may be different than reported as a result the low intensity of the study.

1. Small Mammals and Birds

Wildlife species within the permit area are restricted almost entirely to small mammals and birds. Six genera of rodents, two genera of rabbits, and 32 species of birds were observed during the study. Many birds utilizing the area were migrants. Most of the mammals and breeding birds observed on the permit area are widely distributed, abundant, and relatively tolerant of human activity.

Both units have undergone extensive disruptions (see Land Use). The north unit has been disturbed less and supports populations that are more sensitive to disturbance than those of the south unit (e.g. mourning doves, cedar waxwings, and a breeding pair of red-tailed hawks).

Species distribution within the proposed permit area varies with the available cover. Five habitat types plus a disturbance type were delineated (see Vegetation). A summary of wildlife population by habitat type is presented below. Disturbed types were not sampled and have been omitted from the following discussion.

The rubber rabbitbrush/grassland is the most common habitat type in the proposed permit area. Small mammal densities of the deermouse, vole, and chipmunk population were estimated at 12.9, 15.2, and 0.9 per acre, respectively. Two species characteristic of open areas (Richardson's ground squirrel and the white-tailed jackrabbit) also occupied this habitat type. Only four species of breeding birds were present, which indicated the lowest diversity of all types sampled. The lark sparrow and western meadowlark were the only breeding birds in the south unit. Horned lark and vespers sparrow were other breeding species in the north unit.

Grassland types were not intensively sampled, but probably are similar to the rubber rabbitbrush/grassland habitat due to their structural similarity.

The tree habitat types compose a smaller amount of the study area (23 percent) than the open types, but contain a greater variety of species. Aspen is the most frequent tree type (20 percent of total permit area) and is slightly more diverse than the rubber rabbitbrush/grassland type. Six breeding bird species were found: warbling vireo was most common, followed closely by mountain chickadee, American robin, and western tananger.

Aspen stands within the area probably are impacted by ongoing disturbances. The number of breeding bird species present compares unfavorably with that of other states. Winternitz (1980) found from 10-24 breeding species in the aspen study areas. Depending on the site, from 50 to 100 species were observed using the aspen type at one time or another. Only 32 species were seen in all habitat types in the proposed permit 158 area.

Small mammal populations in the aspen types were not as intensively sampled as within rubber rabbitbrush/grassland habitats. The deermouse was the only species captured in the trap lines. It is likely that chipmunks, which were seen in other habitats, were also present but were not susceptible to sampling. The golden-mantled ground squirrel was seen in rocky areas. Lagomorphs (rabbits and hares) were represented by the mountain cottontail.

The willow type is limited to 1 percent of the proposed permit area and is usually found along drainage bottoms. Total species diversity was similar to the aspen type. Mammal populations were essentially as described above with the addition of northern pocket gophers on disturbed sites within the habitat. Breeding bird diversity was similar in the aspen and willow types (6 and 7 repsectively), but species composition was different. The most abundant species in both types was the warbling vireo. Only three other species were common to each: the American robin, wester tananger and yellow-rumped warbler. The willow type appeared to support more ground foragers (e.g. dark-eyed junco and chipping sparrow), than aspen types.

Lodgepole pine occupies 2 percent of the total permit area. This habitat type is found only in the higher elevations of the north unit. The largest number of breeding bird species (11) for a single habitat was found within this type. With the exception of the yellow warbler, every species found in aspen and willow habitats was found in the lodgepole type. Three additional breeding species were also found. Hein (1980) found an average of eleven bird species in lodgepole pine communities. The lodgepole pine communities appear to be one of the few undisturbed types in the permit area.

2. Large Mammals

Intermediate and large mammals were not common on the permit areas. Dogs were the most common predators and were observed as individuals and in packs of up to seven animals. Domestic cats were the only other predator seen and were much less frequent than dogs.

Big game species were seldom observed on the area, probably because of previous disturbances. The area probably is only used by transient individuals. Direct evidence of their presence is limited to one sighting of mule deer in each unit. Indirect evidence in the form of tracks and scats indicated the occurrence of both elk and black bear in the permit area.

Maps provided by U.S. Forest Service (Rudio, 1980) indicate an elk winter range and an area of moderate summer use north of the proposed permit area. A mule deer and moose concentration area is located across Interstate 15 east of the proposed area. Big game species seen on the study area probably came from these outlying areas.

3. Aquatic Community

Streams within the area are relatively short and intermittent. Disturbances from past mining and highway construction have occurred along many of the streams. None of the streams provides adequate habitat for maintenance of fish populations. Although no systematic sampling has been completed, aquatic life is probably restricted to pollution-tolerant invertebrates.

E. HYDROLOGY

1. Surface Water

The proposed permit area is drained by tributaries to Silver Bow Creek which forms a major part of the headwaters of the upper Clark Fork River. This discussion focuses on the upper Silver Bow Creek basin and extent the upper Clark Fork River basin. Both drainages are affected by Anaconda Copper Company's Butte operations.

a. Proposed waste dump area

The drainages that flow through the general area of the waste dumps originate in the steep mountains east of Butte (fig. II-1). All streams in the area are intermittent or ephemeral. Maximum flows generally occur in the spring in response to melting snow or rainstorms. Occasional midwinter thaws or intense summer rainstorms cause high flows; the rest of the year the streams are usually dry.

The streams are relatively pristine east of Interstate 15. Some of the streams have been noticeably disturbed west of I-15 as a result of past and present mining (Hydrometrics, 1980).

1) South dump area

The following small intermittent streams lie within the proposed permit area: the upper end of Horse Canyon Creek, part of both the upper and lower segments of China Gulch, most of Saratoga Gulch, and a small part of Tramway Gulch (see fig. II-2).

Horse Canyon Creek is an intermittent stream that drains the Columbia Gardens area. It has a drainage area of about 1,150 acres above the Montgomery Avenue settling ponds. This stream is estimated to have a normal baseflow of 10-20 gallons/minute (gpm), with peak flows ranging

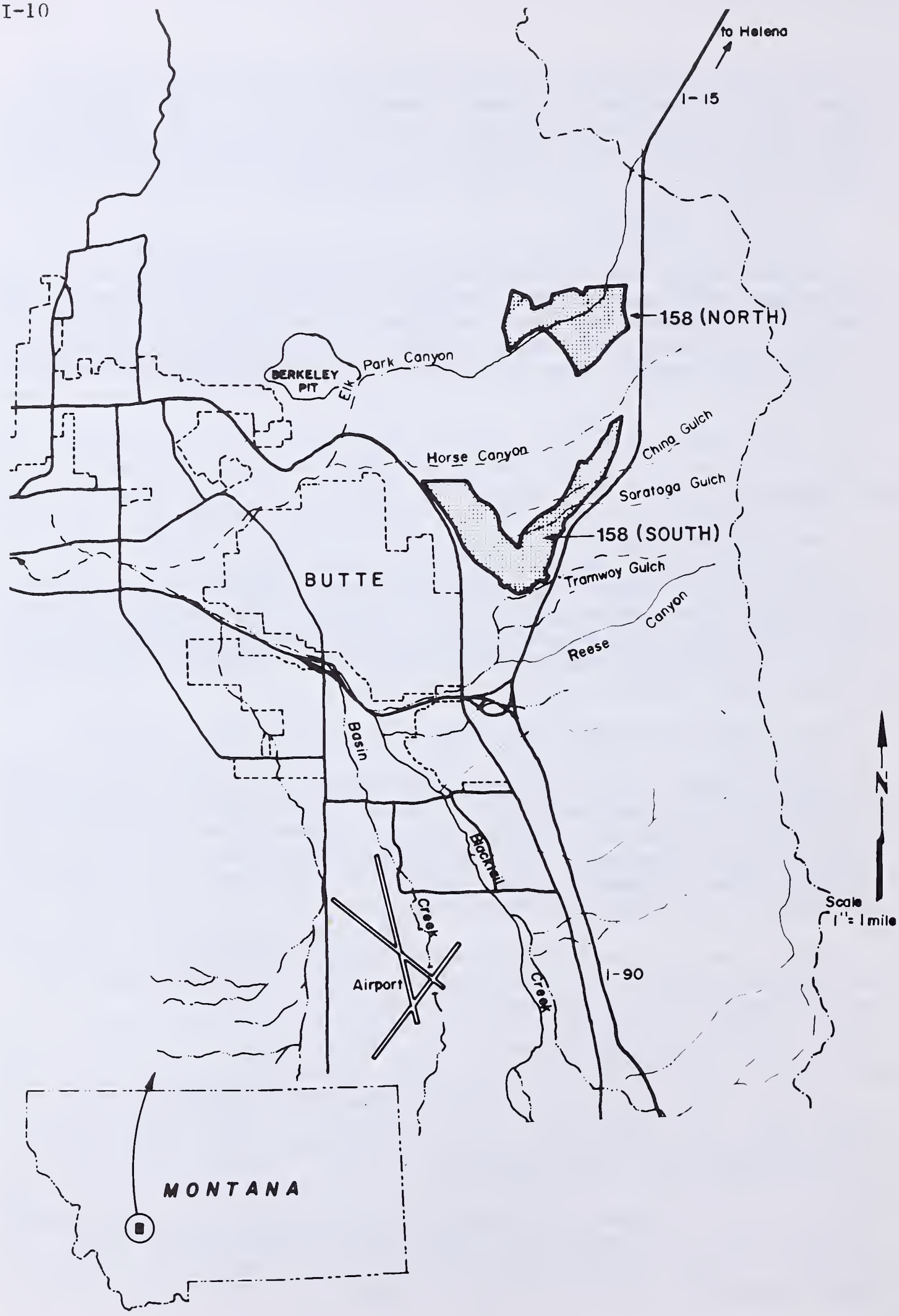


FIGURE II-2.--Surface drainages near the proposed permit area. Source: Hydrometrics, (1980).

from probably 1,300 gpm (2-year runoff event) to 23,000 gpm (100-year runoff event) (Hydrometrics, 1980, p. 7). Horse Canyon Creek was used to to transport treated water (very acidic and high in metals) from Anaconda's Continental East mining operation to settling ponds immediately downstream. Since the Company is no longer mining in the Continental East pit, the water quality of the lower portion of Horse Canyon Creek has undoubtedly improved. All the runoff from Horse Canyon Creek is captured by the Montgomery Avenue settling ponds where it evaporates or infiltrates into the ground water.

China Gulch Creek has a drainage area of 345 acres above the existing south dump. West of I-15, it flows beneath a waste dump, reappears, then ponds and flows beneath the northwest corner of the existing south dump. It reappears on the west edge of the dump and is directed by a ditch to the Montgomery Avenue settling ponds. Normal baseflow of China Gulch Creek is probably between 2 and 15 gpm with peak flows estimated at 3,000 gpm (10-year runoff event) to 11,000 gpm (100-year runoff event).

Saratoga Gulch Creek is diverted by a ditch and 30-inch corrugated metal pipe around the existing south dump. This system delivers uncontaminated water to the Berkeley Complex clearwater ditch. Normal baseflows in Saratoga Gulch were estimated at a few gpm with peak flows estimated to be similar to those of China Gulch Creek (Hydrometrics, 1980, p. 7).

Tramway Gulch Creek passes just south of the south dump, then bends southward passing through the Hillcrest subdivision, eventually joining Reese Canyon Creek.

Samples taken from May through August 1980 show that waters in upper and middle Saratoga Gulch, upper China Gulch, Tramway Gulch, and upper Horse Canyon Creek are very hard, with low to moderate concentrations of dissolved solids--primarily calcium-sulfate types. With the exception of moderate to high manganese and iron, concentrations of metals generally are low. Runoff water from disturbed areas contains higher concentrations of major ions and metals, and thereby lowers the quality of the ephemeral streams flowing through the area. Suspended sediment concentrations in streams are low to moderate (Hydrometrics, 1980, p. 11).

2) North dump (Elk Park Canyon) area

Elk Park Canyon Creek drains about 1,200 acres west of the Continental Divide. It has no major tributaries. This creek is diverted around the Berkeley mine to the Metro Storm Drain and then to Silver Bow Creek.

Periodic streamflow measurements of Elk Park Canyon Creek (November, 1977 to December, 1979) show flows ranging from 0 gpm to 800 gpm. The base flow is usually low--20 to 50 gpm--and usually infiltrates into the underlying sediment in the lower reaches of the stream (Hydrometrics, 1980, p. 9).

Water in this stream is a very hard, calcium-sulfate type with low-to-moderate concentrations of dissolved solids. Concentrations of manganese and zinc are moderate. Other metal values are low (Hydrometrics, 1980, p. 14). There are numerous disturbances in the Elk Park Canyon drainage, including old exploration workings, highway cuts and fills, adits, railroad tunnels and drill holes (John Spindler, Anaconda Copper Co., written commun., December 9, 1980). The disturbances are probably the major cause of the moderate concentrations of manganese and zinc.

b. Tailings pond area

Silver Bow Creek above Anaconda's mill tailings ponds is relatively pristine. A cutthroat trout captured in Silver Bow Creek above the tailings pond had low concentrations of heavy metals, an indication of fairly good water quality (WESTECH, 1980, p. 23).

Yankee Doodle Creek also flows into Anaconda's tailings pond. It is a major source of water for the City of Butte, with the excess runoff ending up in Anaconda's tailings pond. All regulated physical, chemical and biological levels of Yankee Doodle Creek are within State and Federal standards. The waters are slightly alkaline and are considered relatively pristine (Montana Energy and MHD Research and Development Institute, 1979, p. 10).

c. Silver Bow Creek

Until recently, the copper mining and milling industry at Butte and Anaconda discharged acid mine drainage and tailings slurries into Silver Bow Creek and the Clark Fork River. This destroyed aquatic life in Silver Bow Creek and severely depressed aquatic life in the upper Clark Fork River. In the 1950's, Anaconda constructed tailings ponds on Silver Bow Creek near Warm Springs (U.S. Environmental Protection Agency, 1977). Lime is mixed with the water flowing into the ponds to settle heavy metals and nutrients. The ponds remove about 70 percent of the cadmium and 98 percent of the copper and zinc entering the ponds (Beuerman and Gleason, 1978, p. 33).

The Warm Springs ponds steadily improved the quality of water down-river (Casne and others, 1975), until the mid-1960's, when they began to fill, reducing the retention time of incoming water. High winds occasionally stirred the pond waters, resuspending flocculated solids which were subsequently carried to the Clark Fork River. This damaged the sport fisheries that had been reestablished in the Upper Clark Fork River (Spindler, 1977).

In 1972, Anaconda put into operation a new primary waste treatment system at Butte. A system of ditches and ponds capture most contaminated water on site. The contaminated water is sent to a tailings pond in the Silver Bow Creek-Yankee Doodle Creek drainages for clarification.

Water discharged from Anaconda's Butte operations still occasionally exceeds the standards for some metals and pH set by the Montana Water

Quality Bureau (Dick Montgomery, U.S. Environmental Protection Agency, Helena, Montana, oral commun., November, 1980). During 1980, copper, zinc, iron, total suspended solids, and pH values were all above the discharge standards at times (Dick Pedersen, Montana Department of Health and Environmental Sciences, oral commun., November, 1980).

The wide variation in pH is due to large changes in the amount of water released from the system. A manual acid feed system is used to lower the pH of discharge water; the amount of acid added depends on how much water is recycled. It is difficult for the operator of the acid feed system to control the flow of acid to match the discharge. The company has agreed to install an automated system which will be activated by the pH of the discharge and balance it accordingly. This should help alleviate this problem (Dick Montgomery, oral commun., November, 1980).

Silver Bow Creek is no longer used to transport mill tailings and is starting to show signs of recovery with insects and aquatic flora reappearing. However, Silver Bow Creek is still plagued by pollution problems that will limit complete recovery until pollution sources are reduced (U.S. Environmental Protection Agency, 1977, Beuerman and Gleason, 1978, Montana Department of Health and Environmental Sciences, Anaconda-Butte Operations Permit Files, 1981). The major sources of pollutants are municipal, industrial discharges, City of Butte storm drains, and old mine tailings located in the Silver Bow flood plain (Montana Water Quality Bureau, 1980, p. 226). The old Colorado mine tailings are suspected of contributing up to two-thirds of the copper and zinc load in Silver Bow Creek (Beuerman and Gleason, 1978, p. 32; U.S. Environmental Protection Agency, 1977, p. 15).

d. Clark Fork River

Sulfate ion concentrations in the Clark Fork River from Garrison to Drummond have exceeded the Montana Water Quality Standards (250 milligrams/liter) by as much as 32 percent between August, 1977 and July, 1978, (Botz and Karp, 1979, p. 6). The Warm Springs and Opportunity settling ponds are probably major contributors of sulfates to the Clark Fork River. These ponds effectively remove most of the metals and other dissolved constituents from waters of the Silver Bow Creek and discharges from the now defunct Anaconda Smelter. Without the ponds, both sources of pollutants to the Clark Fork River would degrade the water quality and appreciably limit aquatic life in the upper reaches of the Clark Fork River.

With the recent closure of the Anaconda Smelter, the levels of metals and nutrients in the Clark Fork River should decrease. The amount of improvement in water quality has yet to be determined.

Although the ponds appreciably improve the quality of water in the Clark Fork River, a large flood in Silver Bow Creek could conceivably wash out part of the settling ponds which lie across the stream's flood plain. This would wash metal-laden sediment into the Clark Fork, having a detrimental effect on aquatic life. The U.S. Army Corps of Engineers is evaluating this problem. As long as the Anaconda Company is controlling the flow of water into the headwaters of Silver Bow Creek, the probability of a flood damaging the Warm Springs Ponds is small (U.S. Environmental Protection Agency, 1977, p. 8).

2. Ground Water

a. Silver Bow Valley

Ground water is readily available in the Silver Bow Valley. In the last 10 years use of ground water for domestic purposes has become more widespread, as has the use of septic tanks for waste disposal (Botz, 1969, p. 1). Ground water is also used for industrial purposes, stock watering, and irigation (Botz and Karp, 1979, p. 1). The primary source of ground water in the Silver Bow Valley is unconsolidated valley fill and stream-laid alluvial deposits along the lower portion of the valley.

Wells in the granitic igneous rocks of the Boulder batholith which underlie most of the Silver Bow Valley generally produce small-to-moderate (up to 100 gpm) quantities of ground water.

Figure II-3 shows the elevation of the top of the ground water table in the Silver Bow Valley. Ground water generally moves down-valley and toward Silver Bow Creek. Silver Bow Creek downstream of its confluence with Blacktail Creek gains water from the ground water system. The ground water table surfaces along Silver Bow Creek just west of Butte creating a marshy area (fig. II-3). Additional marshy land probably existed along the creek before miners began to pump large amounts of ground water out of the underground shafts.

Ground water quality in the Silver Bow Valley is generally good except for localized areas below the confluence of Silver Bow Creek and Blacktail Creek where ground water is not suitable for human consumption. Most of the wells downgradient of the confluence are abandoned or used only for lawn watering. The old Colorado mine tailings, septic tanks, subsurface waste disposal, and the highly mineralized rocks around Butte all contribute to this ground water pollution; the relative contributions are not known. Some of this contaminated ground water enters Silver Bow Creek adding to the creek's pollution problems.

b. Effects from Anaconda's Butte operations

At present Anaconda pumps about 5,000 gallons per minute (gpm) of inflowing ground water from the 2,200 foot elevation level of the Kelley shaft. The removal of ground water, which has gone on for nearly 100 years, has modified the height of the ground water table near the Berkeley Pit. Before large-scale underground mining began at Butte, ground water flowed from north of Butte and from the East Ridge area towards Silver Bow Creek. Much of the ground water north of Horse Canyon is now diverted downward towards the underground pumping network, as shown by the tightly-spaced contours near the Berkeley Pit (fig. II-3). The pumping system

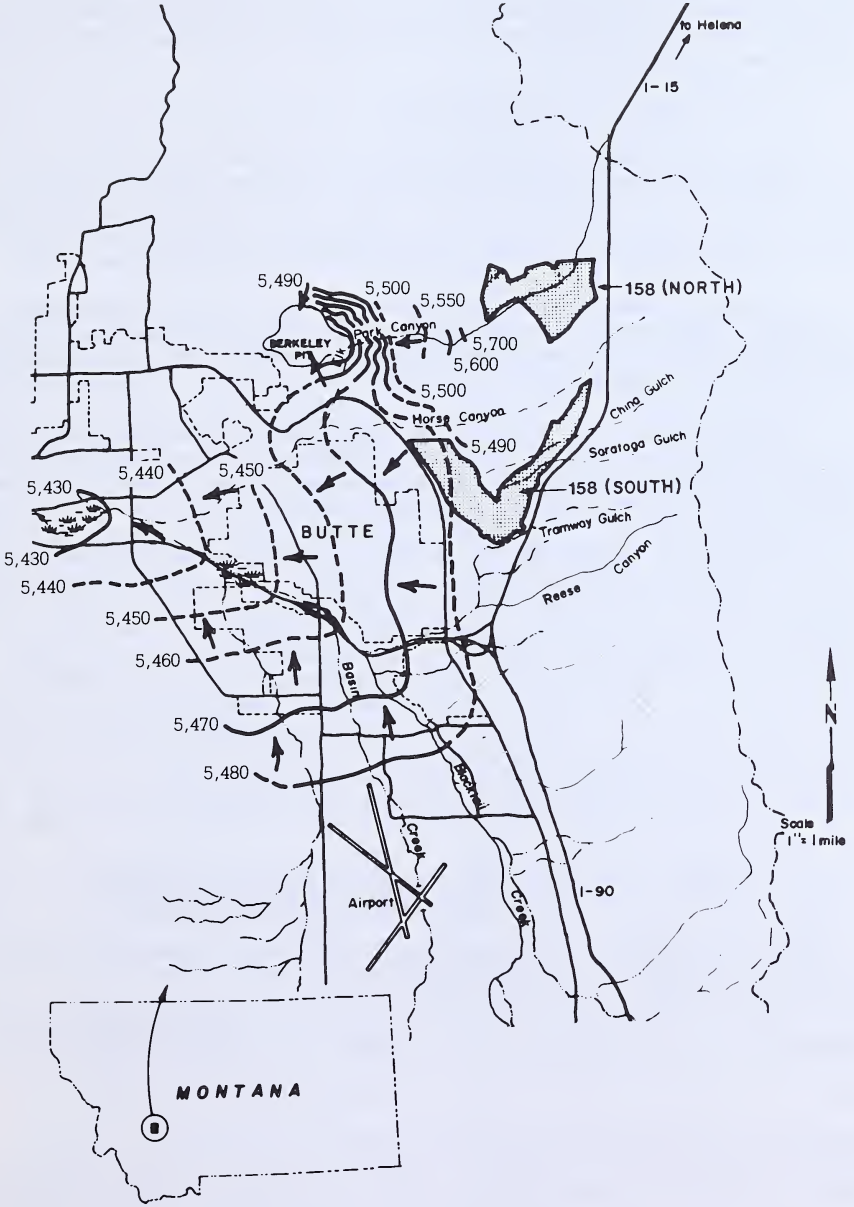


FIGURE II-3.--Ground water elevations and flow directions near the proposed permit area. Source: Hydrometrics, (1980).

collects most of the ground water that is contaminated by mining and discharges it to the tailings pond north of the Berkeley Pit. There, the acidic, highly mineralized water is neutralized with lime which precipitates most of the metals.

c. Proposed waste dump sites

Wells in the granitic rocks in Elk Park Canyon (site of the proposed north dump) could probably produce small to moderate (up to 100 gpm) quantities of water although no drill tests have been done. The fractures through which ground water passes are usually discontinuous and pumping would quickly deplete the available ground water (Hydrometrics, 1980).

Although it has not been sampled, ground water in Elk Park Canyon is probably hard with low-to-moderate concentrations of dissolved minerals and concentrations of dissolved metals greater than the maximum allowable in drinking water (Hydrometrics, 1980).

A well drilled into the alluvium immediately west of the existing south dump produced roughly 15 gpm. The quality of water from this alluvial well met the suggested drinking water limits, except for magnesium, which was much higher than the suggested limits.

Ground water in the bedrock under the south dump probably is similar to that sampled in the Continental South area: high in iron, copper, zinc and manganese (table II-2). Manganese and zinc are mobile and once in suspension they are not readily precipitated or removed from solution (John Spindler, Anaconda Copper Company, written commun., December 9, 1980). Both minerals are probably present in the ground water and surface water due, at least in part, to the natural reaction between infiltrated precipitation and mineralized rock. Some surface disturbances related to mining activities over the past 100 years have exposed some mineralized rock. As a result, the ground water quality samples taken in the Continental South area and within the alluvium may be slightly degraded compared to undisturbed areas.

TABLE II-2.--Continental South ground water quality (units of measure = miligrams/liter)

[Source: Corbett, 1974, Memorandum on Continental-South water study to J.C. Spindler, Anaconda Company, Butte, Mont., April 4, 1974.]

Parameter	2/24-26/74	4/1/74	Recommended limits for drinking water
pH	---	5.2-8.09	---
Copper	1.6-6.5	0.11-62.0	1.0
Iron	0.05-0.95	---	0.3
Zinc	0.93-1.55	0.05-5.2	5.0

Water percolating through the waste rock in the existing south dump may pick up metals from the waste rock and carry it into the ground water. Ground water samples in a well located downgradient of the existing south dump had very low levels of metals and near neutral pH, indicating that significant amounts of poor quality water from the dump are not presently reaching the alluvial ground water (see Table III-4). This potential pollution source is discussed in chapter III, Hydrology; pumping of the pit and underground workings currently prevents significant amounts of contaminated ground water from the south dump area from reaching the Silver Bow Valley.

d. Warm Springs and Opportunity industrial ponds

Ground water below and downgradient of the Warm Springs and Opportunity industrial ponds is presently degraded by seepage of poor quality pond water. Even so, no ground water wells have been reportedly contaminated by this seepage. Some of the degraded ground water especially high in sulfates eventually ends up in the surface waters of the Clark Fork River, adding slightly to the pollution problems of the River. The industrial ponds effective in removing a major part of the pollutants contained in Silver Bow Creek and that derived from the Anaconda Smelter operations. The localized ground water pollution problem around the ponds is a minor source of pollution when compared to the ponds' effectiveness in removing pollutants from the surface waters of Silver Bow Creek and the Clark Fork River.

F. GEOLOGY

1. Regional Setting

The Butte mining district, which includes Anaconda's Berkeley mine, is located on the southwestern edge of the Boulder batholith--a large granitic body that rose to the earth's surface some 70-80 million years ago. The rich deposits of copper and other minerals found at Butte owe their origin to the intrusion of the Boulder batholith although the deposits were probably not formed until some 10 million years after the main granitic intrusion. The Boulder batholith is composed of several distinct intrusions. The Butte quartz monzonite--a granitic rock containing a high proportion of quartz--forms the main mass of the batholith. Most of the important ore deposits associated with the Boulder batholith occur within the quartz monzonite or along its contact with adjacent rocks (Meyer and others, 1968, p. 1378).

2. Butte Mining District

The Butte mining district has the largest known mineral concentration associated with the Boulder batholith. Miller (1973) contains a detailed discussion of the geologic and mining history of this district. See also chapter II, Social Conditions, history section.

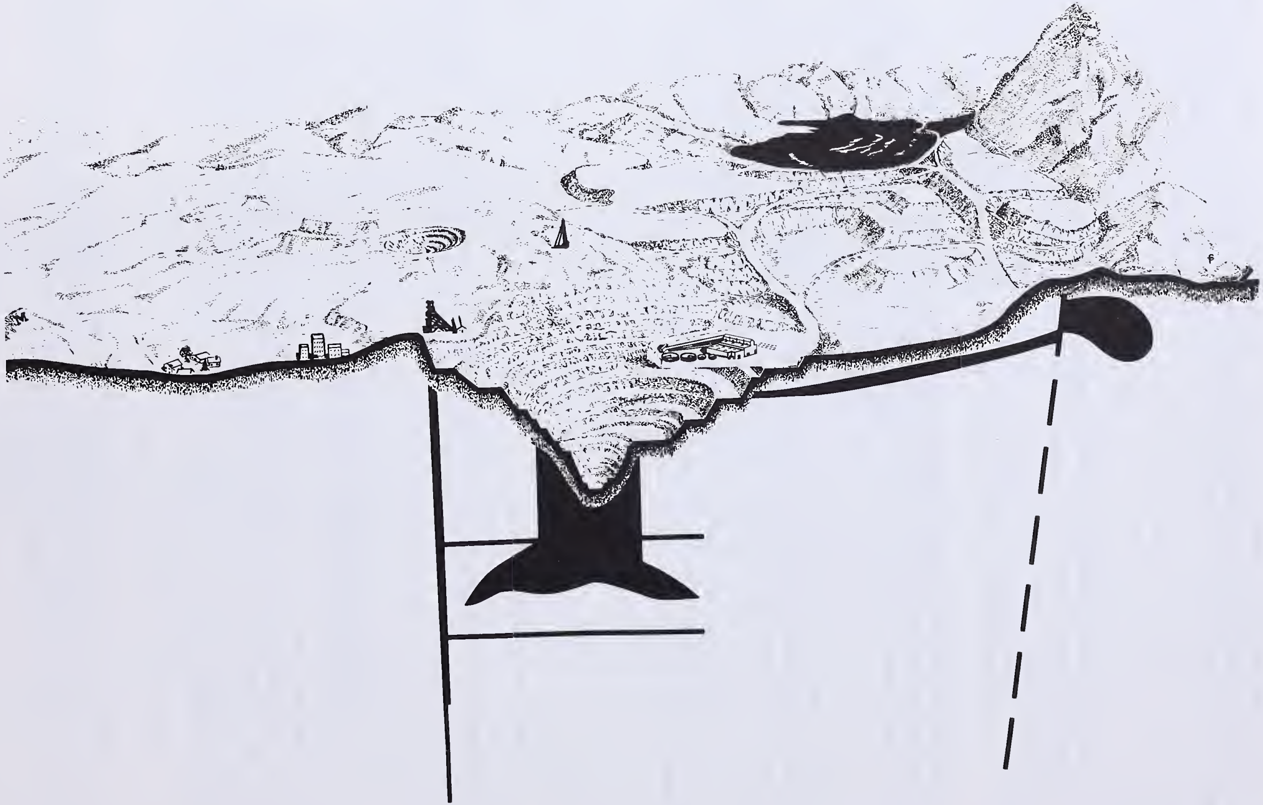


FIGURE II-4.--Mineralized zone underneath and east of the Berkeley Pit. Dashed line shows continental fault; solid lines show projected Kelly Mine block caving operation.

In addition to gold, silver, and copper, the Butte district produced considerable quantities of zinc, manganese, and lead, in addition to minor amounts of cadium, bismuth, arsenic, selenium, and tellurium (Meyers and others, 1968, p. 1,376). Nearly all of the ore from Butte's underground mining came from rich veins and closely-spaced mineralized fractures (Meyer and others, 1968, p. 1,381). The larger veins are upwards of 10's of feet thick; some have been mapped over 5 miles in distance and to depths as great as 4,500 feet (Meyer and others, 1968, p. 1,392).

Open pit mining at Butte began in 1955, capitalizing on the massive deposit of copper ore that occurs in both rich veins and in low grade mineralized blanket below the surface. The mineralized blanket or zone of supergene enrichment was formed by the downward percolation of fluids that leached copper and other metallic minerals from mineralized veins; the veins have since been mostly eroded away. The mobilized minerals were carried downward a short distance and redeposited in a confined layer, or "blanket", and then disseminated throughout the existing rocks. These supergene deposits are important contributors of copper ore although the concentrations are low. At present, open-pit mining is the only economical method to mine the low grade deposits.

The copper zone mined at the Berkeley Pit narrows at about 2,800 feet elevation. Below that level, a zone of quartz-molybdenite veins (a source of molybdenum and some copper) widens giving the overall mineralized zone the shape of an hourglass (fig. II-4).

Additional copper and molybdenite reserves lie east of the Berkeley Pit (fig. II-4). Between the Berkeley Pit and the Continental Fault, the supergene enrichment blanket lies under 1 to 500 feet of alluvial gravels and barren waste rock (leach cap). East of the Continental Fault, additional copper and molybdenite veins occur and the ore is closer to the surface due to faulting along the Continental Fault system.

3. Faults and Earthquakes

The probability of a damaging earthquake at Butte is remote, but one could occur within the lifetime of the Anaconda operations. The Continental fault system (several faults grouped together) east of the Berkeley Pit has the greatest potential of all the faults in the area for creating a damaging earthquake.

Butte is near the Intermountain Seismic Belt, which extends through Yellowstone Park, Bozeman, Three Forks, Helena, Helmville, and ends near Kalispell. Because Butte is adjacent to this zone of higher-than-normal earthquake activity, some of the strain on the earth's crust could be translated to the faults in the Butte area. No earthquakes have been directly tied to movement along the Continental Fault at Butte, but accurate instruments capable of detailing movement on this fault were not installed until about 10 years ago. Chapter III, Geology discusses the possibility of a major earthquake occuring in Butte.

4. Proposed Waste Dump Sites

The north dump site in Elk Park Canyon is mostly underlain by fractured and faulted granitic bedrock. In the drainage bottom, a narrow strip of unconsolidated alluvial (stream-laid) and colluvial (slope wash) deposits of unknown depth is present.

The south dump area is underlain by variable depths of alluvium and colluvium. The alluvium is the thickest in the southwest corner of the proposed dump and is probably 100 to 200 feet thick. Most of the remainder of the dump site is composed of bedrock.

G. CLIMATE

1. Precipitation

Total precipitation (measured at the Butte airport 4.5 miles SSE of the Berkeley Pit) has varied from 6.4 inches to 20.6 inches/year since 1905. The annual average total precipitation since 1951 is 11.5 inches. During a normal year, 70 percent of the total precipitation occurs during the potential growth season--April through September. May and June, the wettest months, receive 34 percent of total annual precipitation. Monthly precipitation is highly variable; for example, mean June rainfall ranges from 0.25 inches to over 5.75 (fig. II-5b). Thornthwaite's (1931) P-E index, a relative measure of effective precipitation, classifies the Butte area as a semiarid humidity province with a moisture deficiency occurring throughout the year. June, which has the highest monthly precipitation, also has the highest P-E ratio. That is, the greatest amount of precipitation available for plant growth, soil formation, and soil erosion occurs in June (fig. II-5c).

Meteorological data collected at the Alpine and Hillcrest sites (fig. II-6) during 1978-79 indicate that conditions near the south dump are drier and warmer than at the airport. During those two years the annual mean precipitation and temperature at the airport were 10.42 inches and 38.1°F respectively. At the south dump during the same period, the annual mean precipitation was 9.03 inches, 15 percent less, and the annual mean temperature was 2° warmer, 40.1°F. The drier conditions at the south dump would increase the difficulty of reclamation (see chapter III, Vegetative Reclamation).

The annual mean number of days receiving at least 0.01 inches of precipitation, an amount assumed to be sufficient to control fugitive dust emissions during that day (U.S. Environmental Protection Agency, 1972) is 107. The greatest rainfall received during 24 hours since 1902 was 2.02 inches in August, 1955. This size storm can be expected about once every 25 years, while a 2.8-inch storm in 24 hours can be expected every 100 years (table II-3). Mean annual pan evaporation is about 35 inches, 80 percent of which occurs from May through October (U.S. Department of Commerce, 1968).

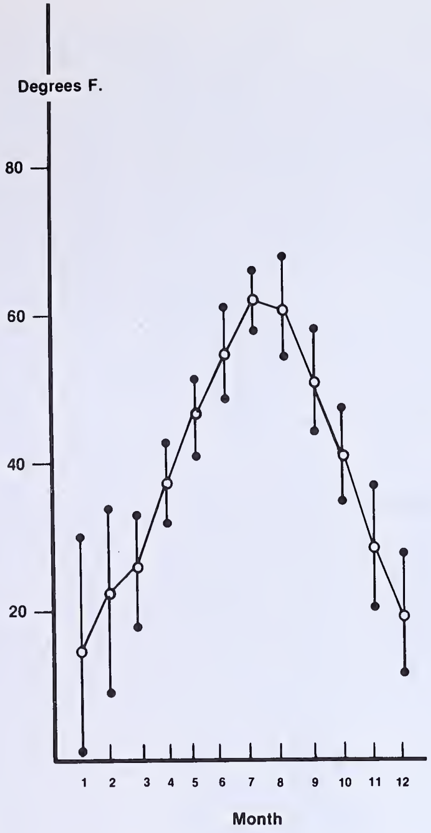


FIGURE II-5a.--Monthly Butte temperature: average (open circles) and range (solid circles) at Butte Airport, 1951-1979.

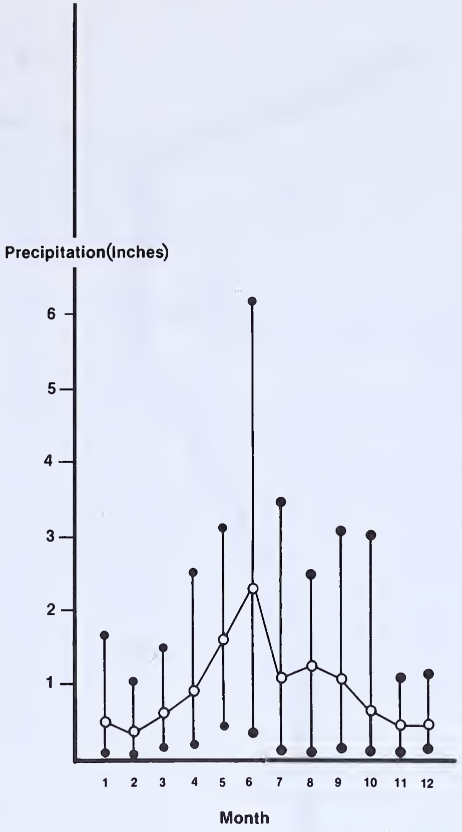


FIGURE II-5b.--Monthly Butte precipitation: average (open circles) and range (solid circles) at Butte Airport, 1951-1979.

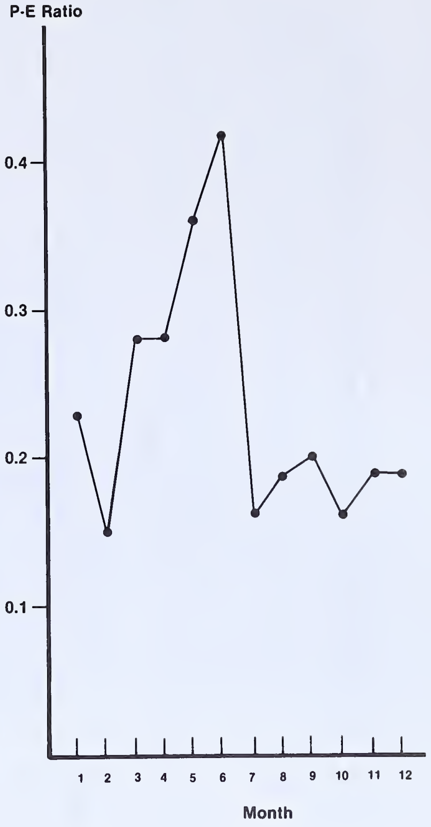


FIGURE II-5c.--Precipitation effectiveness in Butte.

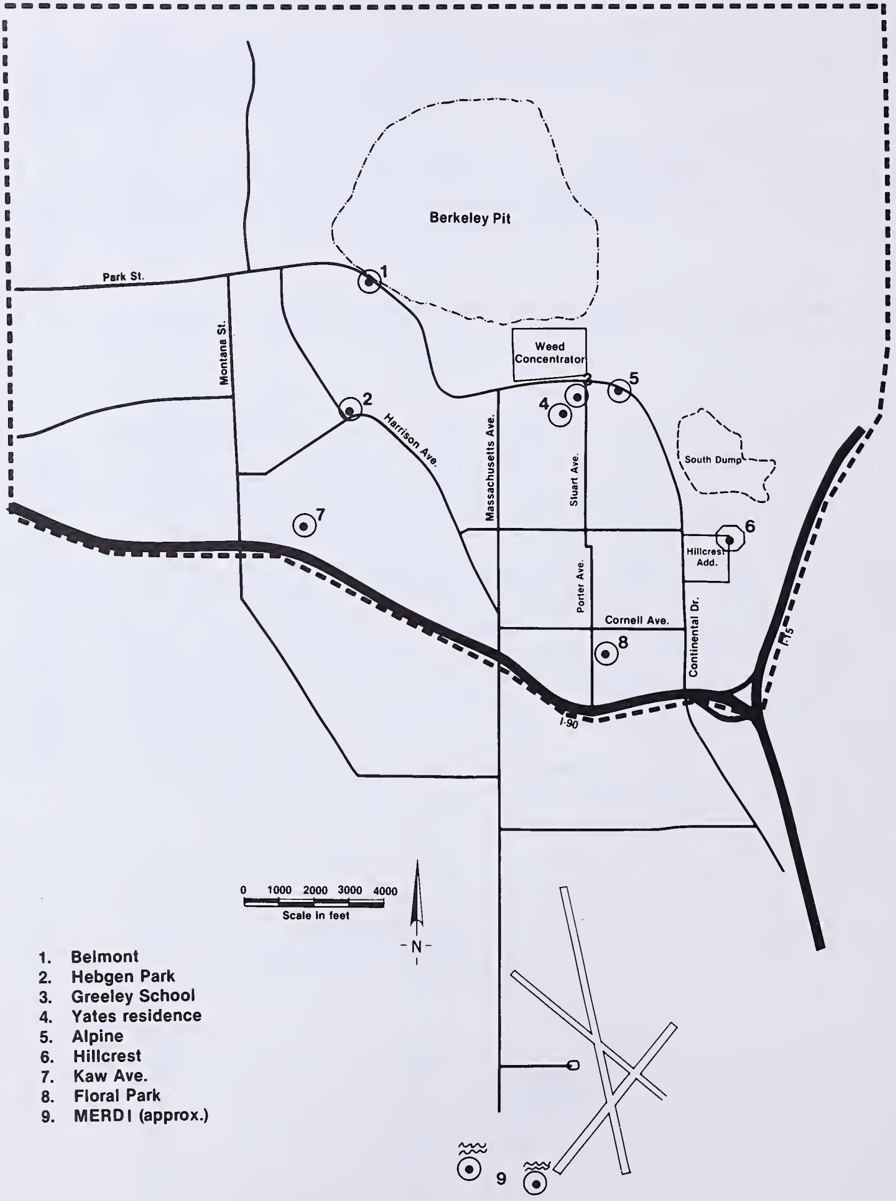


FIGURE II-6.--Location of meteorological and air quality stations. Dashed line shows boundary of TSP nonattainment area. Circles show air quality stations; hexagon shows meteorological station.

Snow can occur during any month and averages about 50 inches/year. Over 60 percent of the annual total falls from December through March; about 20 percent of the annual total falls in March alone. The largest 24-hour snowfall on record was 30.0 inches on October 10, 1911, and the greatest monthly total was 41.5 inches during May of 1927. Thunderstorms and heavy fog occur about 40 and 6 times a year, respectively.

Yearly average relative humidity ranges from 81 percent at 5:30 a.m. MST to 52 percent at 5:30 p.m. MST. Seasonal average relative humidity ranges from 73 percent during the winter to 56 percent during the summer.

TABLE II-3.--Maximum amount of precipitation expected at Butte during various time intervals

[Source: Miller and others, 1973]

Length of Event (hours)	Amount of Precipitation (inches) Number of Years Considered 2	5	10	25	50	100
1	0.5	0.7	0.8	0.9	1.0	1.1
6	0.8	1.0	1.2	1.4	1.5	1.7
24	1.2	1.6	1.8	2.2	2.6	2.8

2. Temperature

The average annual temperature at the Butte airport, based on records from 1951-1979, ranges from 34.0°F to 41.7°F with a mean of 38.7° F. July and August are the warmest months, averaging over 60°F; January is the coldest, averaging 15.5°F. The range of average temperatures in the winter is much greater than during the remainder of the year (fig. II-5a). The temperature extremes range from -55°F (February, 1933) to 100°F (July, 1931). The normal freeze-free period is 60 days, but freezing temperatures can be expected any time of the year. There is a 50 percent probability that a temperature below 32°F will occur after June 9 and before August 17.

3. Winds

The wind data used in this EIS are from the Anaconda Company Hillcrest Station unless otherwise noted. Although this station has been in operation for only 2 years, data from it are more relevant than those collected elsewhere due to the site's proximity to the permit area and mining operations. Data from the Federal Aviation Administration at the Butte Airport and from the other Anaconda Company stations are on file at the Department of State Lands. The location of these stations is shown in figure II-6.

For the 26-month period November, 1977 to January, 1980, surface wind speed (33 feet above ground level) averaged 1.3 miles/hour blowing

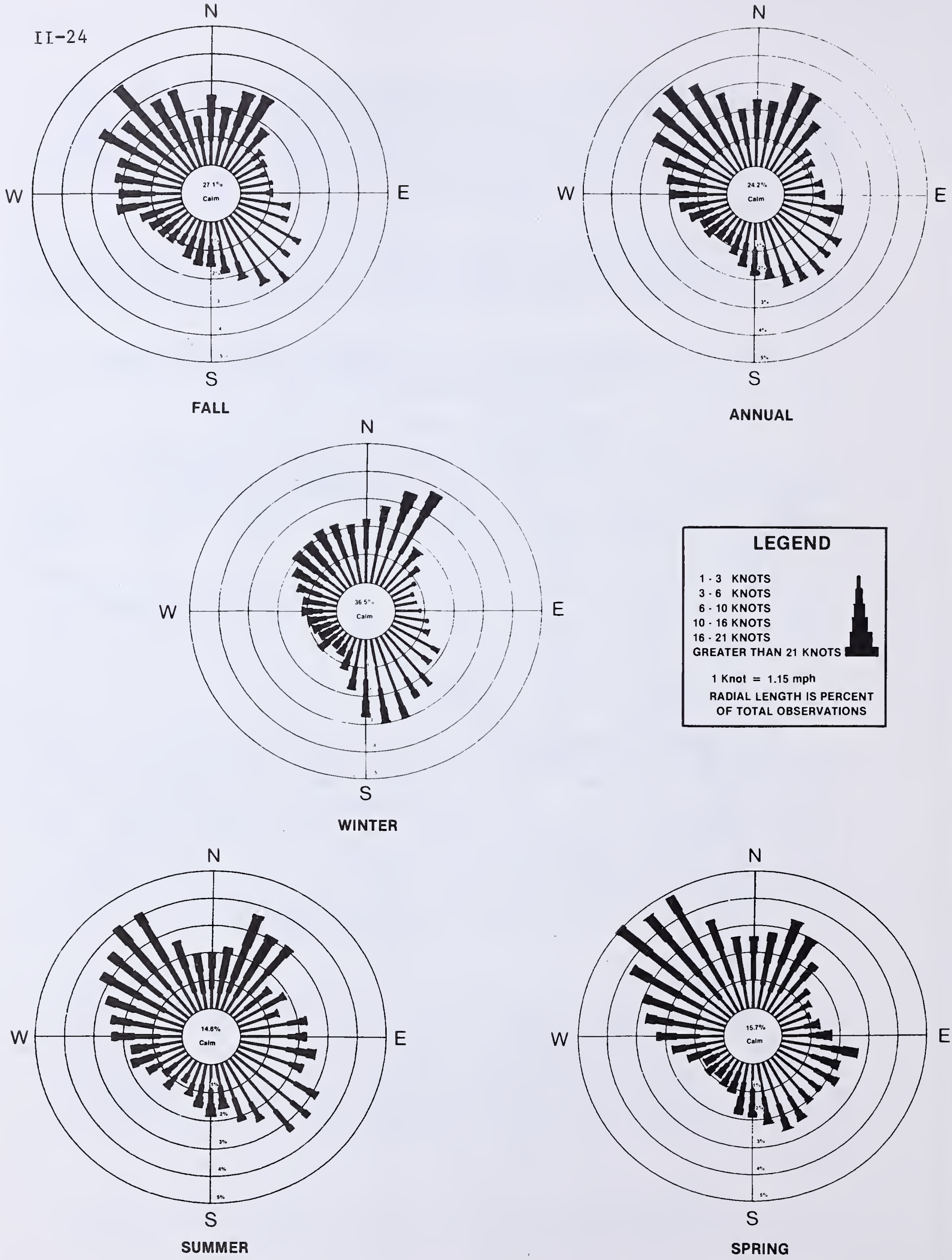


FIGURE II-7.--Seasonal and annual wind roses at the Anaconda Copper Company's Hillcrest meteorological station.

from the north to northwest (average from 334°). Calm periods occurred almost 25 percent of the time. Seasonally, winds blew from all directions much of the time. Only during the spring was there an obvious prevailing wind, from the northwest (fig. II-7). The wind roses (fig. II-7) show that calm periods are frequent, ranging from 15 percent of the time in the summer to 36 percent in the winter, and that low wind speeds predominate. Due to these low wind speeds, wind erosion at Butte is not a major problem.

The Butte valley is a very poor area for the dispersion of air pollutants. Over 80 percent of the time atmospheric stability is from neutral to very stable; conditions which are not conducive to the dispersion of air pollutants. Based on the recorded Butte airport data, the National Climatic Center (1972) has determined the stability class frequency distribution (table II-4).

The Butte valley is ideal for the formation of strong and persistent temperature inversions (temperature increases rather than decreases with altitude). The altitude, relative dryness, long winter nights, lack of cloudiness, and frequent snow cover during winter favor heat radiation, which causes strong ground cooling and inversions. Inversions are also enhanced due to the sheltering effects of surrounding mountains which produce low wind speeds and calms and by the cold air that drains into the valley from the mountain slopes at night.

TABLE II-4.--Atmospheric stability class frequency distribution at the Butte Airport

Stability Class	Frequency (percent)[1]
A--very unstable	1
B--unstable	8
C--slightly unstable	9
D--neutral	45
E--stable	10
F--very stable	26

[1] Total does not equal 100 percent due to rounding.

The seasonal and annual inversion frequencies at Butte were interpolated from maps prepared by Hosler (1961). Winter (December, January, and February) has the highest frequency of inversions and spring the lowest (table II-5). The figures in table II-5 may be somewhat less than the true values because the effects of the Butte valley are not considered.

TABLE II-5.--Seasonal and annual inversion frequency

Season	Frequency (% of total hours)
Winter	50
Spring	32
Summer	34
Fall	45
Annual	40

These inversions inhibit vertical atmospheric mixing and dilution of air pollutants. During inversion conditions with low mixing heights, pollutant concentrations would build up and the highest total suspended particulate (TSP) concentrations would occur. The mixing heights for the Butte area are estimated to be lowest in winter with a daily average of 2,000 feet above ground level, and highest in summer, averaging 5,200 feet above ground level (table II-6). Wind speed through the mixing layer varies from 9 miles/hour on summer mornings to 18 miles/hour during most afternoons (table II-7).

A potential air pollution episode is defined as a situation lasting at least 2 days with no precipitation, mixing height equal to or less than 5,000 feet, and the average wind speed through the mixing layer equal to or less than 9 miles/hour (U.S. Environmental Protection Agency, 1972). During a 5-year period, 25 to 100 such air pollution episode-days could be expected in Butte. A maximum of 100 episode-days for episodes lasting 5 days or longer could be expected during this same 5-year period (Holzworth, 1972).

TABLE II-6.--Mixing heights (feet above ground level)

[Source: Holzworth, 1972]

Morning		Afternoon	
Annual	1,300	Annual	6,600
Winter	1,300	Winter	2,600
Spring	1,600	Spring	7,900
Summer	1,000	Summer	9,500
Fall	1,300	Fall	5,600

TABLE II-7.--Wind speed (miles/hour) through mixing layer

[Source: Holzworth, 1972]

Morning		Afternoon	
Annual	13	Annual	18
Winter	16	Winter	18
Spring	13	Spring	18
Summer	9	Summer	13
Fall	13	Fall	18

H. AIR QUALITY

1. Summary

The present air quality in Butte is poor. Total suspended particulate (TSP) concentrations exceed both Federal and Montana ambient air quality standards (AAQS) for both the annual and 24-hour standards (table II-8). This particulate consists of relatively high concentrations of benzene-soluble hydrocarbons, copper, lead, cadium, arsenic, and zinc, some or all of which may be responsible for the abnormally high respiratory disease and cancer death rates occurring in Butte (Maughan, 1981). Although the criteria pollutants (nitrogen oxide, sulfur oxide, ozone, and carbon monoxide) do not exceed State and Federal standards, the ambient concentrations may act synergistically with the particulates to increase the risk to human health and welfare.

2. Pollutant Concentrations

The northeast section of Butte, including the Berkeley Pit, does not meet the Federal or Montana ambient air quality standards (AAQS--table II-8) for total suspended particulate (TSP). Therefore, this area was designated a nonattainment area in 1978 for exceeding these standards.

The nonattainment determination for the Butte area was based on TSP concentrations measured by the Montana Air Quality Bureau (MAQB) at the Greeley School site (fig. II-6). However, the primary annual AAQS for TSP of 75 ug/m^3 has also been exceeded at the Alpine, Belmont, Yates, and Hebgen Park sites (fig. II-6 and table II-9) in the area. The TSP concentrations decrease rapidly with distance from the mining operations. The Anaconda Copper Company (ACC) Hillcrest site, 1.5 miles southeast of the Weed Concentrator, measured a mean TSP concentration of 45 ug/m^3 while the Montana Energy Research Institute site, 6 miles south of the Weed Concentrator, recorded mean TSP concentrations of only 17 ug/m^3. Thus, it would appear the mining operations and city central activities are the major sources of particulate. Results from air quality modeling efforts by three different groups (PEDCo, 1978; ERT, 1978; and MAQB, report on file with Department of State Lands) and the calculation of

TABLE II-8.--Ambient air quality standards (AAQS)

Pollutant	Averaging Time	Montana	Federal Primary[a]	Federal Secondary[b]
Total Suspended Particulate	Annual	75ug/m^3[b]	75ug/m^3	60ug/m^3
	24 Hour	200ug/m^3[f]	260ug/m^3	150ug/m^3
Sulfur dioxide	1 Hour	0.50ppm[e]	---[h]	---
	3 Hour	---	---	0.5ppm
	24 Hour	0.10ppm[d]	0.14ppm	---
	Annual	0.02ppm[f]	0.03ppm[f]	---
Carbon Monoxide	1 Hour	23ppm[4]	35ppm	35ppm
	8 Hour	9ppm[4]	9ppm	9ppm
Lead	90 Days	1.5ug/m^3[f]	1.5ug/m^3	1.5ug/m^3
Nitrogen dixoide	1 Hour	0.30ppm[d]		
	Annual	0.05ppm[f]	0.05ppm[f]	0.05ppm[f]
Settled Particulate	30 Days	10g/m^2[f]	---	---
Nonmethane Hydrocarbons[g]	3 Hour (6-9 a.m.)	---	0.24ppm	0.24ppm
Photochemical Oxidants (ozone)	1 Hour	0.10ppm[d]	0.12ppm	0.12ppm

[a] Federal ambient air quality standards with averaging time less than 1 year are not to be exceeded more than once per year.

[b] Arithmetic average; not be exceeded.

[c] Geometric mean; not to be exceeded.

[d] Not to be exceeded more than once per year.

[e] Not to be exceeded more than 18 times in any 12 consecutive months.

[f] Not to be exceeded.

[g] Set as a guide to achieve photochemical oxidant standards.

[h] --- indicates no standard.

emissions from sources in the area substantiate this conclusion. The estimated TSP concentration map (fig. II-8) is based on the Montana Air Quality Bureau model.

The modelling work performed by the three groups estimates that the Anaconda mining operation contributes from 38 to 55 percent of the TSP concentrations recorded at the Greeley School site. At the Hillcrest site the amount of TSP caused by the mining operation is 32 to 36 percent (fig. II-9). The particulate emitted from the mining operation does not travel far from the Berkeley Pit as shown by the low TSP concentrations measured 6 miles downwind of the operation. This concentration of 17 ug/m^3 is similar to the particulate concentrations found in pristine areas of Montana (U.S. Department of Interior and Montana Department of State Lands, 1979).

The particulate in the Butte ambient air contains many trace metals presently considered to be carcinogenic. Nickel, chromium, arsenic, and cadmium are known to cause cancer in man; beryllium, cadmium, cobalt, chromium, iron, nickel, lead, titanium, and zinc have been reported to cause cancer in animals (Fraumeni, 1975; Sunderman, 1978, 1979). A particulate sample from the Hebgen Park site (Montana AQB, 1981) contained all of those metals in the respirable fraction (the portion of particulate capable of deep penetration into the lungs).

Hydrocarbons are also present in the Butte ambient air in concentrations ranging from 4 to 6 ug/m^3 (table II-9). These compounds contribute to the formation of photochemical smog, especially in the presence of ozone and nitrogen oxides. Some hydrocarbons, for example benzo(a)pyrene [B(a)P], are also known animal carcinogens. Although only one winter particulate sample was analyzed for B(a)P, the concentration, 0.125 ug/m^3, was exceptionally high. Normal urban B(a)P concentrations range from 0.002 ug/m^3 to 0.007 ug/m^3. The major sources of hydrocarbon emissions in Butte are diesel and automobile exhaust; smoke from wood-burning stoves would also contribute to the B(a)P concentrations, especially during the winter (on-file report, Montana Department of State Lands).

Dustfall, a measure of the larger particles which settle out of the atmosphere relatively quickly, was greatest at the Belmont station (fig. II-6), which is closest to the mining operation (9.75 gm/m^2/month--table II-10). This does not exceed the Montana AAQS of 10 gm/m^2/month. The decrease in settleable particulate with distance from the mining operation does not follow the pattern of lowered TSP concentrations. The data in table II-10 indicate that perhaps 75 percent of the large particulate settles out close to the mine; a background level of about 2 gm/m^2/month is normal for the Butte area. This is similar to dustfall rates in pristine areas of southeastern Montana (U.S. Department of Interior and Montana Department of State Lands, 1979).

These large particles contain measureable amounts of trace and potentially toxic metals (table II-10). As would be expected, the Belmont site also recorded the highest levels of these elements. The higher lead levels at the Alpine site are probably due to its proximity to Continental Drive and the lead emitted in motor vehicle exhaust.

TABLE II-9.--Ambient pollutant concentrations in Butte

	Particulate (ug/m^3)											Gases (ppm)			
		Dichotomous Sampler		Benzene-Soluble											
Site	TSP	<2.5u	2.5-15u	Hydrocarbons	Cu	Pb	Cd	As	Zn	SO_4	NO_3	NO_2	O_3	CO	SO_2
Hillcrest	45.0	---	---	3.9	0.49	0.098	.002	.012	.097	1.53	---	---	---	---	---
Alpine	109.0	20.0	31.7	4.7	0.59	0.20	.003	.023	.096	2.20	---	---	---	1.0	---
Belmont	111.1	20.5	25.7	4.5	0.62	0.36	.009	.113	.27	2.37	---	---	---	---	---
Kaw Ave.	64.2	14.0	15.3	4.6	0.35	0.27	.006	.016	.14	2.17	---	---	---	---	---
Yates Residence	92.0	---	---	10.6	0.32	0.31	.007	.020	.20	6.42	---	---	---	---	---
Hebgen Park	92.2	20.3	28.0	---	---	0.37	.007	.021	.18	4.9	2.0	.024	.021	0.90	.008
Floral Park	62.7	18.1	18.9	---	---	---	---	---	---	---	---	---	---	---	---
Greeley School	83.7	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MERDI Sites (Average)	17.0	---	---	---	0.351	0.022	.001	.007	.039	0.84	---	.005	---	---	.007

All pollutant concentrations at all sites, except the MERDI (all pollutants) and Belmont (benzene-soluble hydrocarbons and metals) were recorded after construction of the south dump had ceased. The TSP concentrations were based on fiberglass filters. The benzene-soluble hydrocarbons, metals and sulfates were collected on Whatman filters.

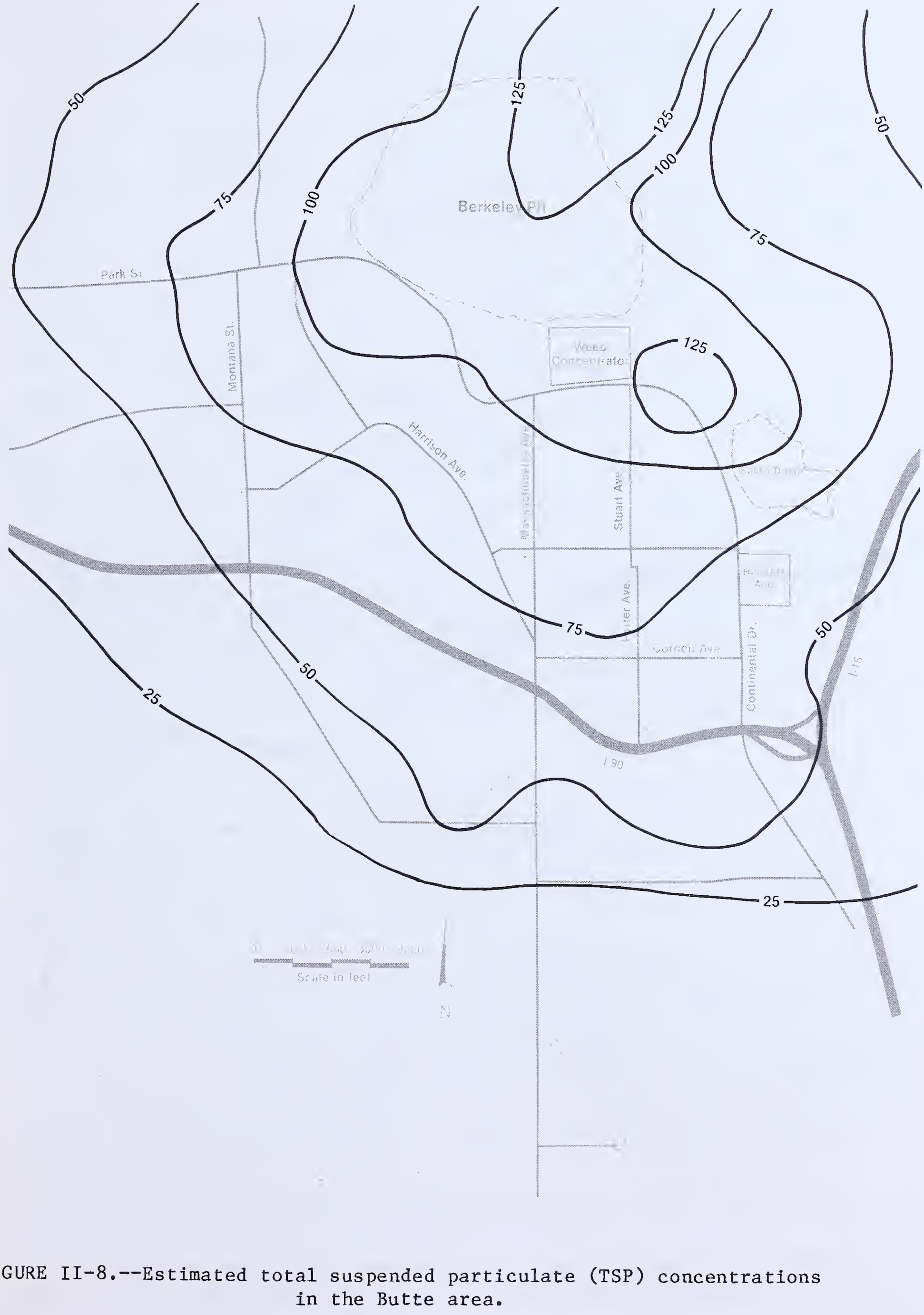


FIGURE II-8.--Estimated total suspended particulate (TSP) concentrations in the Butte area.

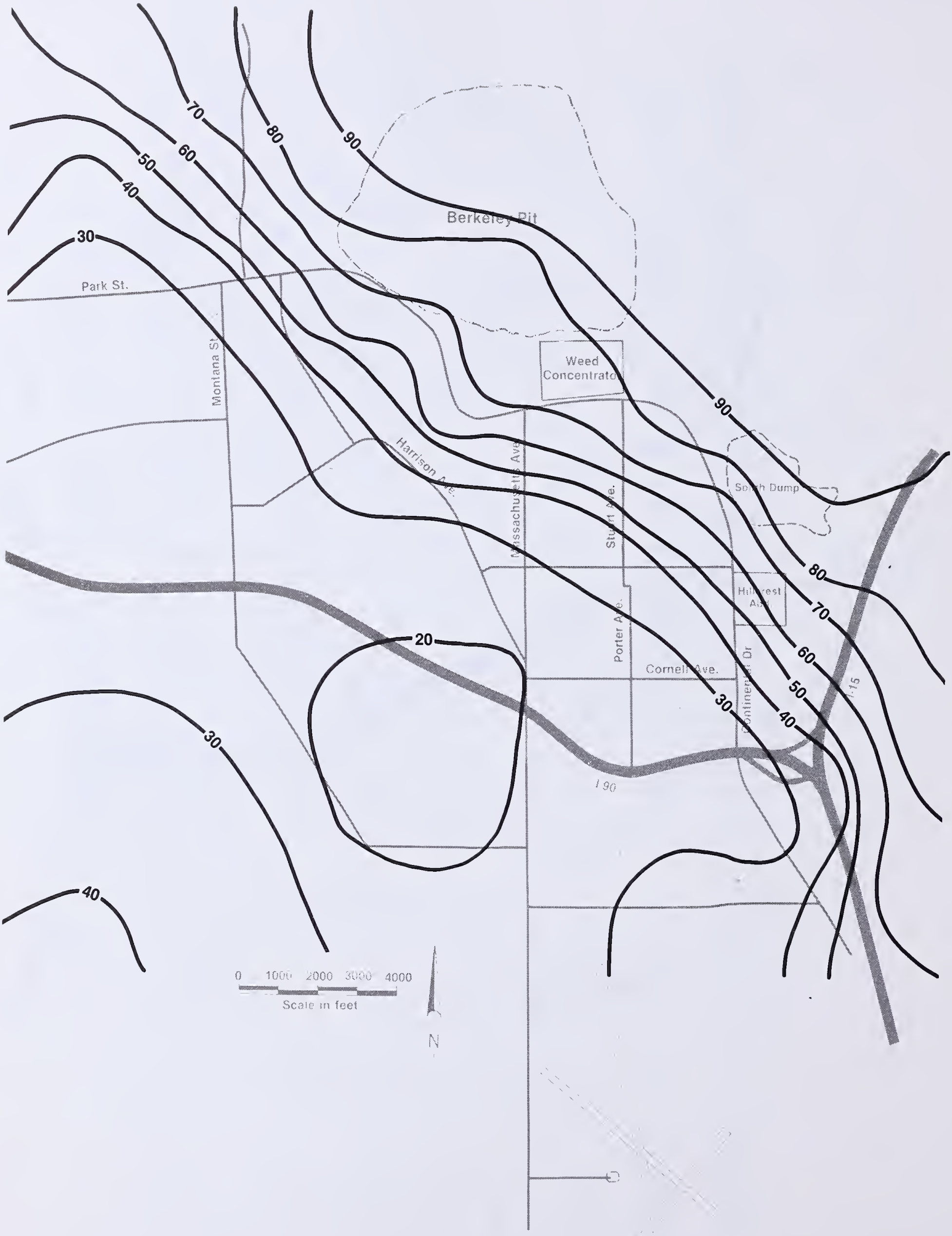


FIGURE II-9.--Isopleth map of the estimated percentage of total suspended particulate (TSP) due to mining, 1979.

TABLE II-10.--Settled particulate (dustfall)(gm/m^2/month)

Station	Period of Measurement	Total Settled Particulate	Pb	Cu	Zn	Cd	As
Belmont	8/79-12/79	9.75	.011	.093	.057	---	.004
Alpine	6/1/78-12/31/79	2.71	.062	.023	.024	---	<.001
Hillcrest	6/1/78-12/31/79	2.06	.005	.014	.014	---	.001
Kaw	6/78-12/79	1.94	.002	.011	.013	---	<.001
Merdi	1/1/78-12/30/78	2.02	.003	.002	.007	<.001	<.001

3. Pollutant Sources

Motor vehicle traffic, the Anaconda Copper Company mining operation, and space heating are the major sources of pollution in the Butte Valley, accounting for 43 percent, 42 percent, and 15 percent respectively of total pollutant emissions (table II-11). The pollutants emitted in the greatest amounts are carbon monoxide (CO) and fugitive dust, accounting for 45 percent and 42 respectively of total pollutant emissions. There are, however, substantial amounts of hydrocarbons (HC), nitrogen oxides (NO_x), and combustion particulates (table II-11) also emitted into the ambient air.

The Anaconda Company mining operation is responsible for 72 percent of the fugitive dust (particulate) emissions in Butte (table II-11); these emissions are, in turn, responsible for the Butte area's noncompliance with Federal and Montana AAQS for TSP. It must be noted, however, that all the calculated emissions are estimates based on equations developed for use at any mine and have not been validated for the Anaconda operation. They should be used for comparison only.

Haul road traffic, primarily 120 and 170 ton ore and waste rock haulers, is the source of 55 percent of the particulate from the Berkeley mine (table II-12). Other heavy vehicles--dozers, graders, and front-end loaders, for example--also produce large quantities of particulate. Wind erosion of all disturbed land within the area accounts for over 8 percent of the total particulate emissions. The Weed Concentrator is a very minor source of particulate accounting for less than 1 percent of total emissions. The dust control measures presently employed at the mining operation are listed in table II-12 with their estimated control efficiency.

Gaseous pollutant emissions from the mining operation (table II-13) are much less than particulate emissions. However, the NO_x and HC emitted may react to form photochemical smog, especially during inversions (see Climate). In conjunction with the particulates, these compounds cause some reduction in visibility, especially during inversions.

Motor vehicle traffic is the major source of carbon monoxide (CO). Traffic on Butte streets also accounts for 28 percent of the particulate emissions, 54 percent of the hydrocarbon emissions, and 23 percent of the nitrogen oxide emissions (table II-11).

Space heating, almost exclusively wood-burning stoves, emits significant amounts of fine combustion particulate into the atmosphere. These particulates are a potential health hazard, given Butte's high frequency of inversions. CO is also emitted in significant amounts (table II-11). Again, since the emissions increase in the winter when inversions are more frequent and severe, the potential health hazards would be the greatest.

4. Human Health Effects

This section is based on a report prepared by the Montana Air Quality Bureau (1981), which is on file at the Montana Department of State Lands.

Based on an examination of death certificates during 1969-1973, deaths caused by respiratory diseases, asthma, emphysema, bronchitis, pneumonia, respiratory system cancer, circulatory diseases, and cerebrovascular diseases (stroke) occurred at a higher rate in Silver Bow County than in the rest of the state. Respiratory cancer death rates in Silver Bow County were 80 percent higher than the Montana average and 54 percent higher than the national average. For this reason, respiratory cancers were used as the basis for this health analysis.

All Butte residents seem to be subjected to substances which increase their cancer and other disease rates. Females of all ages who normally work in less dangerous environments than their male counterparts had death rates from respiratory cancers that exceeded the national and state average by 93 to 148 percent, respectively. Based on interviews of relatives of the deceased, it was found that 80 percent of the deceased were smokers; it is difficult to separate environmental effects from those of smoking. However, airborne toxic compounds inhaled with tobacco smoke worsen the effects of either acting alone.

The Ames test, which responds to organic compounds that are potentially carcinogenic, and a genetic repair assay sensitive for inorganic compounds were used to test for the presence of carcinogens in Butte. Both techniques measure mutations in bacterial strains and are indirect measures of carginogenic activity of a given substance. They detect carcinogenic activity with a reliability of about 90 percent.

Urine samples from school children in Butte and Anaconda were analyzed by the Ames test and repair assay techniques. The results showed that 11 Monroe and Emerson school children from Butte had urine containing significantly high mutagen levels (at least 200 percent that of control

TABLE II-11.--Pollutant emissions (tons) in Butte, 1979

[Source: Pollutant Emissions In Butte, Montana, on-file report, Montana Department of State Lands]

Source	Combustion Particulate	Fugitive Dust	CO	HC	NO_x	SO_x	Aldehydes	Organic Acids	HCN
Anaconda Co.									
Blasting	n/a[1]	6	217	n/a	16	n/a	n/a	n/a	0.5
Diesel Fuel	110.0		1,415	538.0	1,610	228	25	24	n/a
Gasoline	1.7		486	16.7	12	1	n/a	n/a	n/a
Other[2]	n/a	11,918	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SUBTOTAL	111.7	11,924	2,118	554.7	1,638	229	25	24	0.5
Heating									
Oil	1	n/a	1.6	0.3	5.6	14	n/a	n/a	n/a
Gas	39	n/a	42.0	15.0	253.0	1	n/a	n/a	n/a
Wood	317	n/a	4,884.0	229.0	6.6	3	14.5	n/a	n/a
SUBTOTAL	357	n/a	4,927.6	244.3	265.2	18	14.5	n/a	n/a
Motor Vehicles	110	4,580	10,700	899	548	33	n/a	n/a	n/a
TOTAL	579	16,504	17,746	1,698	2,452	280	39.5	24	0.5

[1] n/a = not applicable.
[2] see Table II-12.

TABLE II-12.--Fugitive dust emissions at the Berkeley Mine

Activity	Unit of activity/year	Emission factor	Present control measures	Percent control efficiency	Emissions (tons/year)	Reference
Ore removal (truck & shovel)	18x10^6 tons	0.037 lb/ton	none	0	333	1
Waste rock removal (truck & shovel)	35x10^6	0.037 lb/ton	none	0	648	1
Haul truck traffic[a]	1.456x10^6 miles	18.2 lb/VMT[e]	Water Haul Roads	50	6,625	2
Graders[b]	38,328 hours	32 lb/hour	Water Haul Roads	50	307	1
Dozers[c]	82,125 hours	32 lb/hour	none	0	1,314	1
Rubber-tire loaders[d]	23,500 hours	32 lb/hour	none	0	376	1
Light duty trucks	3.6x10^6 miles	0.68 lb/VMT[e]	Water Haul Roads	50	612	2
Support vehicles	1.2x10^6 miles	1.02 lb/VMT[e]	Water Haul Roads	50	306	2
Waste rock dumping	35x10^6 tons	0.02 lb/ton	none	0	350	3
Drilling	16,875 holes	1.5 lb/hole	none	0	13	1
Blasting	225 blasts	50 lb/blast	none	0	6	1
Concentrator ore dumping	18x10^6	0.007 lb/ton	Baghouse	85	9	1
Conveyors and transfer points	18x10^6	0.2 lb/ton	Baghouse and Water Spray	99	18	1
Crushing						
primary	18x10^6	0.02 lb/ton	Baghouse and Water Spray	99	2	1
secondary	18x10^6	0.06 lb/ton		99	5	1
Wind erosion from exposed areas	4,000 acres	0.25 tons/acre	none	0	1,000	4
TOTAL					11,924	

[a] 56 haul trucks at 26,000 miles/truck/year.
[b] 7 graders at 5,475 hour/grader/year.
[c] 15 dozers at 5,475 hours/dozer/year.
[d] 4 loaders at 4,700 hours/loader/year.
[e] vehicle mile traveled.

[1] U.S. Environmental Protection Agency (1979).
[2] On file reports, Montana Dept. of State Lands
[3] Livingston (1978, p. 15).
[4] ERT (1978, p. B-7).

TABLE II-13.--Diesel emissions from the Berkeley mine

[Source: U.S. Environmental Protection Agency (1976, p.3.2.7-3)]

Source	Fuel Consumption (Gallons)	Pollutant Emission (Tons/Year)						
		Particulate	CO	HC	NO_x	SO_x	Aldehydes	Organic Acids
Haul Trucks[1]	7,100,000	89.0	1343.0	514.0	1247	202.0	19.4	24
Other Trucks	424,000[2]	3.8	20.0	6.4	111	6.6	1.6	----
Dozers--Track Type	500,000[2]	6.3	22.0	6.3	83	7.8	1.6	----
Motor Patrols	240,000[2]	2.7	9.4	2.1	45	3.7	0.5	----
Loaders	132,000[2]	1.9	6.3	2.1	27	2.0	0.5	----
Miscellaneous (Drills, (Compressors, etc.)	392,000[2]	5.9	18.0	6.8	97	6.1	1.3	----
TOTAL[3]	8,788,000	110	1,415	538	1,610	228	25	24

[1] Emission factor used is for 4-stroke switching locomotive [EPA, 1976 p.3.2.2-2] as recommended by EPA (oral commun., David Kircher, 8-20-80 and Chuck Masser, 8-21-80).

[2] Usage figures from ERT (1978).

[3] Rounded to avoid specious accuracy.

levels). No children from Anaconda had mutagen levels that were significantly higher than the controls. The Anaconda smelter was not operating during or one month prior to the collection of the first of two Anaconda samples.

Particulate collected on filters from high volume air samplers at the Hebgen Park monitoring site was also tested for mutagenic substances. Twelve filters, one from each month, were compared with similar filters from other Montana cities. During March 1977 to February 1980, Butte ranked third behind Missoula and Billings in having the most mutagens (as measured by the Ames test) of 10 Montana cities. Butte, however, exceeded all towns in December. Bozeman, with a population similar to Butte, ranked considerably lower in the Ames test results. Thus, residential heating and automobile gasoline exhaust which are of similar magnitude in both Butte and Bozeman could be factored out.

The above results appear to be in good agreement with the effects expected due to ambient organic compound concentrations. Billings traffic and oil refineries and Missoula traffic generate organic pollutants. The extensive use of diesel fuel in Butte added to automobile exhaust and residential heating during extended winter inversions would account for the elevated presence of mutagens during the month of December.

The repair assay, sensitive to inorganic mutagens, was used to measure the mutagenic activity of particulate from filters in 4 cities. Relative values for this preliminary work were: Butte-5, Anaconda-4, Missoula-1, and Scobey-0, with 5 being the highest.

Benzo(a)pyrene, B(a)P, a potent animal carcinogen, is present in the Butte ambient air. Only one winter Hebgen Park site particulate filter was analyzed, but the B(a)P concentration was exceptionally high at 0.125 ug/m^3. Normal urban B(a)P concentrations range from 0.002 ug/m^3 to 0.007 ug/m^3. B(a)P is present in automobile and diesel exhaust and smoke from wood-burning stoves.

Other organic compounds emitted in diesel exhaust include aldehydes, ethers, ketones and phenols. Also present are such inorganic compounds such as carbon monoxide (CO), carbon dioxide (CO_2), sulfur and nitrogen oxides, and lesser amounts of chromium, lead, manganese, phosphorus, chlorine, zinc, copper, and calcium. B(a)P combined with nitrogen oxides form more active mutagens than B(a)P alone.

I. SOCIAL CONDITIONS

1. History

Butte began as a gold mining camp in 1864. Silver mining began 2 years later and by 1870 had replaced gold mining. Silver production rose rapidly; by 1881, Butte was an important mining, milling, and smelting city. The first major copper discovery was made in 1882; by

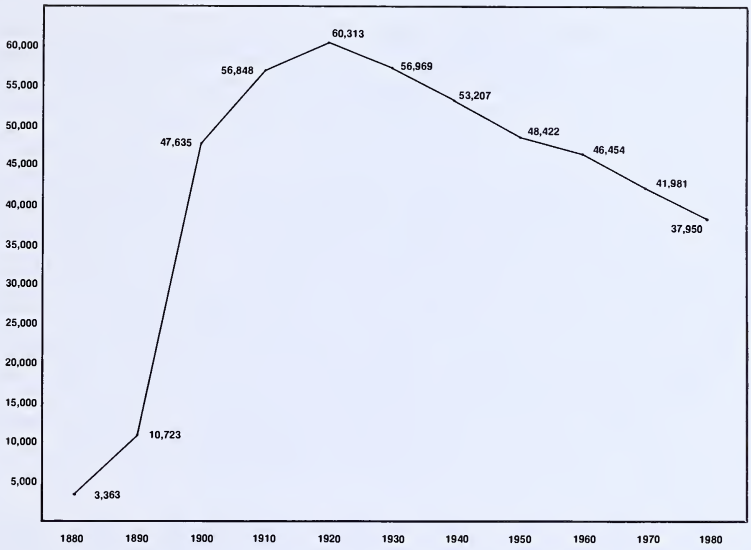


FIGURE II-10.--Population growth in Silver Bow County, 1880-1980.

1885, 25 companies were mining copper ore. The employment and population growth from copper mining gave Butte a permanence not found in other mining camps of that day. By 1900, about 12,000 people were employed in Butte's mining industry (Marcosson, 1957), and the county's population had increased dramatically to nearly 50,000 (see fig. II-10).

The Anaconda Copper Mining Company incorporated in 1891. By 1900 the company was the largest single copper producer in the world and employed nearly three-quarters of the wage earners in Montana. The company also owned municipal waterworks, stores, hotels, street railway systems, sawmills, brickyards, and ultimately six of the seven major daily newspapers in Montana (Toole, 1972, p. 104). The population of Silver Bow County peaked in 1920 at 60,313 (fig. II-10). During the copper boom, Butte's population supported a lively business district, an opera house, and several racetracks. Many social events centered on mining, such as drilling, mucking, and first aid rescue contests. Columbia Gardens was the site of most of these popular social events (see Cultural Resources).

Strong ethnic neighborhoods formed in Butte. There were distinct settlements of Italian, Chinese, Welsh, Cornish, Finnish, Scandinavian, French, Jewish, Lebanese, and Yugoslavian peoples. The population also included thousands of Irish miners who had immigrated from mining areas in England.

When the Anaconda mine changed from silver to copper, the United States was not a copper consumer. Copper demand rose with the use of electrical devices and during the two world wars. Employment in Butte's mining industry fluctuated greatly until 1944, peaking during World War I and II at 15,000 and 9,000 jobs, respectively (Miller, 1973, p. F-5).

Mining in Butte has always been geared to improving profitability through new technologies. The first major change in mining methods began in 1952 when block caving was determined to be profitable (Miller, 1973). Employment dropped significantly as a result. In 1955, surface mining began when the Berkeley Pit was opened. Improved smelting and concentrating technology allowed use of the lower grade ore produced by surface mining. Surface mining in turn allowed the use of technology which substituted capital for labor, greatly reducing employment compared with previous underground vein mining. In 1963, a new copper concentrator at Butte replaced a less efficient technology and further lowered the number of workers needed. Large-scale underground mining operations ended in 1975, cutting Butte's mining employment in half between 1974 and 1979 (see Economics).

The population of Silver Bow County has declined approximately 8 percent each decade since 1920 (fig. II-10). Between 1960 and 1970, net out migration from Silver Bow County was 7,770, or 16.7 percent of the total population -- nearly double the rate for Montana. The population decrease can be attributed entirely to a lack of employment opportunities (Old West Associates, 1978, p. 5).

High out-migration and uncertainty over future mining operations contributed to substantial urban decay in the central business district (CBD) (Old West Associates, 1978, p. 48). Most new construction in both housing and businesses has occured south of the CBD in the "Flats" area since 1970 (see Land Use). Much of the CBD is included in the National Register for Historic Preservation.

2. Description of Butte's Population

The population of Butte-Silver Bow was 37,950 in 1980 (U.S. Department of Commerce, 1981)--about 10 percent lower than in 1970. The proportion of residents of Butte-Silver Bow that are 65 years or older is 12 percent compared to the State norm of 9.5 percent. The population is aging without equivalent replacement from young people. The sex ratio is expected to decline; females will be an increasing proportion of the population, because they have a longer life expectancy than males. Relatively few people of racial minority origin live in Silver Bow County: 1.2 percent of the population compared to Montana's rate of 4.2 percent (U.S. Department of Commerce, 1970).

The Butte community is economically dependent on the Anaconda Copper Company's Berkeley Mine. Changes in the company workings have important repercussions for the people who live in Silver Bow County. When the Anaconda Company experiences large layoffs, the crime rate increases, marriage rates fall, and divorce rates climb (Montana Energy and MHD Research Institute, 1979b, p. 38).

3. Description of the Anaconda Employees

Eighty-eight percent of the Anaconda Company's Butte employees live in Butte and Walkerville, about 6 percent live in Anaconda, and about 4 percent live in Whitehall. The average household size of the employees of the Anaconda Company is approximately 3.5, somewhat higher than the average household size of Butte which is approximately 2.6. This difference may be explained by the age and sex structure of the two groups. The employees of the Anaconda Company are likely to have a larger household size than the rest of Butte's population, because a larger percentage of this group are in the child rearing ages. Eighty-four percent are between the ages of 31 and 59. Eighty-eight percent of the Anaconda Company employees are males; males generally head larger households than females. Sixty-one percent of the employees are married.

4. Description of the Study Area Population

The neighborhoods closest to the south dump were studied by Miller (1980) to determine attitudes toward dumping operations. Information on the attitudes of respondents in the study area are taken from that study. The study area included the fire districts of Floral Park and Racetrack, and the Drives area. Use of the fire district boundaries allowed comparison between the 1980 data and data from a 1976 study which covered the entire urban area. The addition of the Drives area to the fire districts formed a boundary equidistant from the south dump. An estimated 6,800 people live in the study area.

The study area was divided into two subareas to determine if distance from the dump was associated with different responses to questions posed by interviewers (fig. II-11). Significant differences are discussed in text.

The study area is composed mostly of married homeowners with families. Ninety percent of the heads of households are homeowners, indicating a strong commitment to staying in the area. Eighty-seven percent consider their neighborhood a "good" place to live; most heads of households are favorably inclined to their neighborhoods and plan to remain in them. The study area is heavily populated by natives; about half of the heads of households were born in Silver Bow County and two-thirds were born in Montana. This could further indicate a desire to stay in the area.

One-third of the heads of households are in the professional, technical, managerial, and proprietary occupations, compared to 21 percent in the Butte urban area in 1976 (the last year for which data on the urban area were available). In 1976, the average gross income in the area contiguous to the south dump was 22 percent higher than in the rest of the urban area.

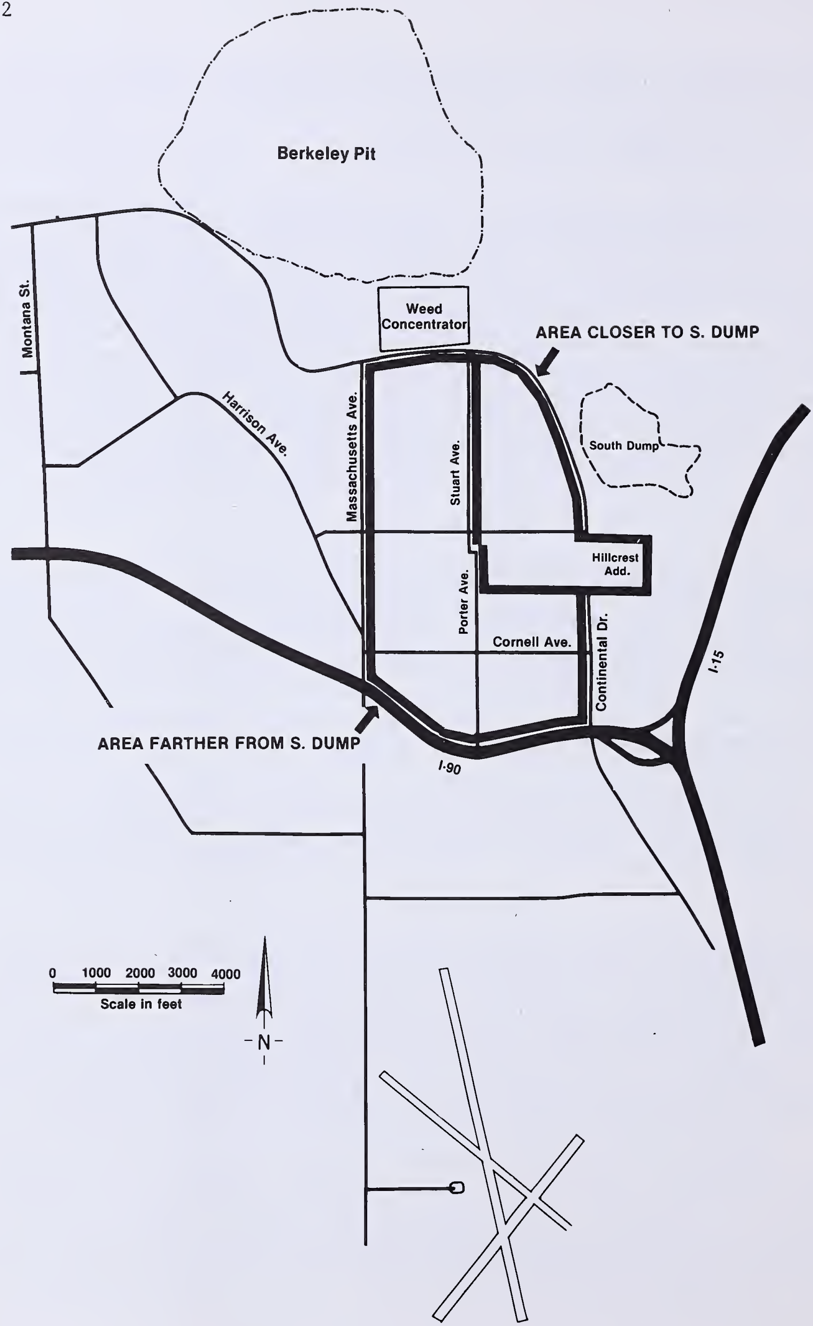


FIGURE II-11.--Location of the two sub-areas sampled during the social survey (Miller, 1980).

Twenty-eight percent of the households in the study area were on fixed incomes in 1979, compared to 40 percent in the Butte urban area in 1976. Most of the households in the study area on a fixed income are older families. Twenty percent of the heads of households in the study area are retired. The median income for these retired heads of households in 1979 was $13,312, substantially less than the income for employed heads of households ($22,487).

Children under 19 total about 35 percent of this population--a very high proportion; people over 65 years of age make up 10 percent of the population. Together, these age groups (which are "dependent" in that they require different services than the working-age population) make up 45 percent of the study area's population.

About 57 percent of the households in the study area have neither family members nor relatives directly involved in mining at Butte.

The neighborhoods in the study area are areas with a sense of community and a high level of social involvement; most persons have close friends within walking distance and many have relatives close by. These neighborhoods show a high degree of mutual aid and support both in terms of material and personal needs.

People feel that the area is relatively quiet and residential in character. However, mine blasting and noise from mining and street traffic were mentioned most often when residents were asked about the negative aspects of their neighborhood. The percentage of residents in the subarea closer to the dump that listed dust as a negative aspect of their neighborhood was 50 percent higher than the percentage of residents in the subarea farther from the dump.

Forty percent of the heads of households in the study area indicated a considerable sense of powerlessness. A great deal of distrust exists towards the Anaconda Company among the residents interviewed. Almost 70 percent of the heads of households do not believe ARCO's assertion that only 20 years of mining remain in Butte. About 75 percent of the heads of households do not feel well-informed about the future propsects of mining in Butte, and almost all of them feel the Anaconda Company controls information to its own advantage. Such attitudes are typical of towns dependent on a single industry. These attitudes may have had an influence on political or legal action regarding the waste dump expansion. It is not known whether similar proportions of residents in other parts of Butte have a similar sense of powerlessness.

Conversely, about 26 percent of the heads of households in the study area indicated no sense of powerlessness; 80 percent believe it is possible for the various groups in the community to get together and work for their collective betterment.

J. ECONOMICS

1. Employment

Mining has been the primary determinant of total employment in Butte and Silver Bow County since 1864. Despite recent work force reductions, copper mining continues to be the most important employer in the county. In each of the decades between 1940 and 1970 a decline in mine employment lead to a decline in population (fig. II-12). The growth in employment after World War II, particularly in trade, transportation, and construction, offset the job losses in mining, but during the 1950's and 1960's employment reductions in mining produced a decline in total employment. During the 1970's, Silver Bow County, like the rest of the nation, had an increasing employment participation rate and a corresponding increase in trade and service sector employment. Population also increased during that time. From 1975-78, however, population declined following the closure of most of Anaconda's underground operations.

During 1980, the Anaconda Company employed 1,696 people in Butte; 861 in the Berkeley Pit and the remainder in the concentrator and administrative offices. On July 1, 1980, as in five previous contract negotiations since 1954, the union employees struck the Anaconda Company. The strike ended 154 days later on November 22, 1980. The longest previous strike was in 1967-68 and lasted 260 days; the shortest was in 1977 and lasted 29 days.

The closure of the underground workings of the Anaconda Company in 1975 accounted for most of the 1,900 Silver Bow County jobs that were lost in the mining industry between 1974 and 1978. Increases in the service industry of 820 jobs, and State and local government of 705 jobs (see table II-14), helped to lessen the effect of the mine work force reduction. About two-thirds of the increase in State and local government is temporary as it results from CETA, a Federally-funded jobs program.

Before the closure of the underground operation of the Anaconda Company in 1975, the unemployment rate in Silver Bow County was comparable to the State rate (table II-15). Between 1975 and 1979 the unemployment rate was higher than the State rate. The Anaconda Company strike did not have a secondary employment effect until October 1980, when the unemployment rate (which does not include striking miners) increased from 6.0 percent to 7.0 percent. This compared to a statewide increase from 5.1 percent to 5.3 percent (Montana Department of Labor and Industry, 1980a). Most of the statewide increase resulted from the closure of the Anaconda smelter and Great Falls refinery, and part of the Silver Bow County increase was undoubtedly due to the same cause.

The proportion of the population employed in Silver Bow County is significantly lower than in the State. Owing to the higher proportion of the population that is over 65 (see Sociology), Silver Bow County's employment-population ratio since 1967 has been about 90 percent of the

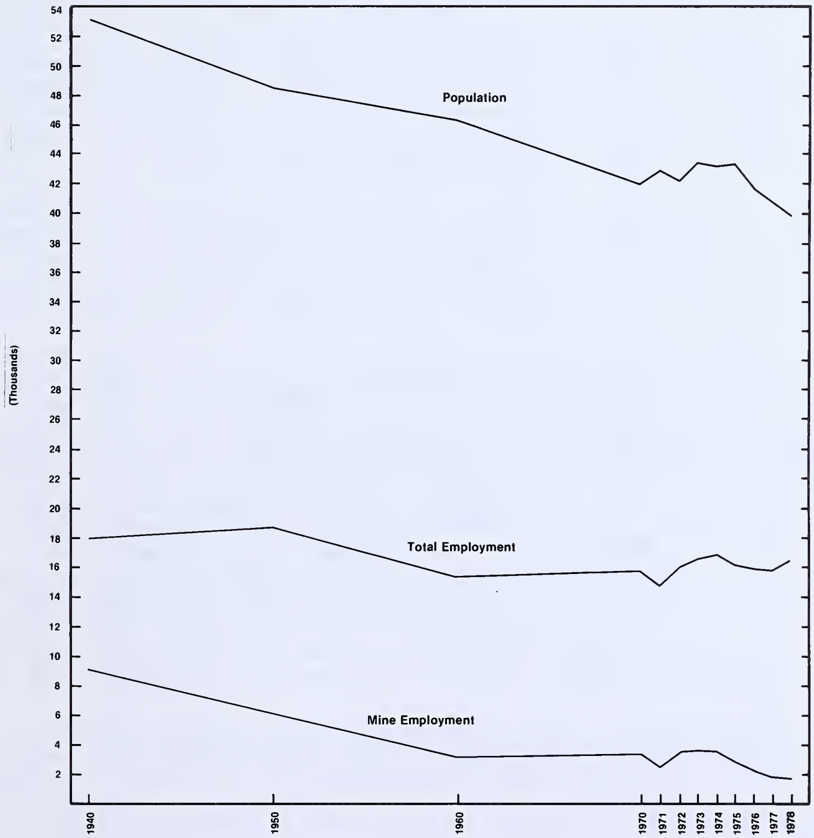


FIGURE II-12.--Mine employment, total employment and population, Silver Bow County, 1940-1978.

Montana ratio. The years when this relationship is significantly different were associated with a major event at the Anaconda Company--strikes in 1967-68, 1971, and 1977; and the closure of the underground operations in 1975.

The effects of the recent smelter closure in Anaconda will not be confined to Anaconda due to the many connections between the economies of Butte and Anaconda. Because there were 157 Butte residents employed at the smelter, and because about 132 workers at the Weed concentrator in Butte will be replaced by Anaconda smeltermen with more union seniority ("bumping"), the effects of the smelter closure is expected to be the dominant feature of Butte's employment picture for the next 5 years. More than 600 Silver Bow County jobs will probably be lost as a result of the smelter closure (staff analysis, on-file report).

Other major employers in Silver Bow County include: Montana Power Company, Montana College of Mineral Science and Technology, Saint James Hospital and Safeway Foods. Together, these employers provide about 2,000 jobs (Montana Energy and MHD Research Institute, 1979a, p. 34).

2. Income

Employees of the Anaconda Company are among the most highly-paid workers in the State. When the 1980 copper strike began, the average worker made about $10.23/hour (Montana Standard, Nov. 22, 1980). This compares to $6.46/ hour in the entire private sector of Montana (Department of Labor and Industry, 1980b, p. 40). The new Anaconda contract calls for a 30 percent real pay increase for Anaconda workers over the next 3 years--an average increase of $3.06 per hour. This is significantly higher than the increases during the previous 10-year period. Real hourly wages (wages adjusted for inflation) in the metal mining industry increased 23.7 percent between June, 1970, and June, 1980, while they decreased in the entire private sector by 7.5 percent. Only the hourly wages in the metal mining and primary metal manufacturing industries have kept pace with inflation over the past ten years in Montana.

Increases in the real hourly wage rate at the Anaconda Company operation have prevented the effects of the past mine work force reductions in Silver Bow County from being felt in full (Polzin, 1980). For example, while employment in mining decreased by 50 percent between 1970 and 1978 (table II-14), total wages (in constant dollars) paid in the county by the Anaconda Company decreased by only 41 percent (Anaconda Company, written communication, June 20, 1980). While exact data is not available, the amount of private retirement income in the county has probably been increasing at a faster rate than the Statewide average and this may also have partially offset the effects of the past mine work force reductions. Because so many Butte households are headed by older persons, transfer payments (social security, military retirement, medical assistance, and the like), have been a consistently greater part of total personal income in Silver Bow County than in Montana as a whole.

TABLE II-14.--Employment by broad industry in Silver Bow County, selected years 1970-78

[Sources: U.S. Department of Commerce (1980); Montana Department of Community Affairs, written commun., 1981]

	1970[a]	1972[a]	1974[a]	1975[a]	1976[a]	1977[b]	1978[b]
Agriculture[1]	216	224	227	170	162	154	152
Mining	3,325	3,395	3,537	2,775	2,148	1,831	1,804
Construction	457	495	470	361	414	491	561
Manufacturing	676	623	690	659	659	631	648
T.U.[2]	726	773	853	824	807	745	713
Trade	3,266	3,537	3,777	3,816	3,832	3,741	3,843
F.I.R.E.[3]	495	454	437	400	429	468	479
Services	2,924	2,629	2,964	3,096	3,350	3,426	3,605
Nonfarm Proprietors	1,117	1,091	1,169	1,160	1,117	1,132	1,211
Federal Government	773	751	733	717	650	632	636
State & Local Government	1,728	1,881	2,073	2,163	2,210	2,484	2,778
TOTAL	15,703	15,853	16,930	16,141	15,778	15,735	16,430

[a] Estimates based on 1967 S.I.C. codes.

[b] Estimates based on 1972 S.I.C. codes.

[1] Includes: farm proprietors, farm wage and salary employment, and agricultural services, forestry, fisheries, and other.

[2] Transportation and public utilities.

[3] Finance, insurance, and real estate.

TABLE II-15.--Unemployment rate in Silver Bow County, selected years 1970-79

[Source: Montana Department of Labor and Industry (1980)]

	1970	1972	1974	1975	1976	1977	1978	1979
Silver Bow Co.	3.9	4.6	5.2	8.1	9.4	9.2	8.2	6.3
Montana	4.3	4.8	5.2	6.4	6.1	6.4	6.0	5.1

Between 1973 and 1978, transfer payments in Silver Bow County averaged 16.3 percent of total personal income. In Montana, transfer payments averaged 11.4 percent of income (U.S. Department of Commerce, 1980). The percentage of total personal income represented by transfer payments in Silver Bow County has increased at a more rapid rate than the Montana.

Because of the relatively high wages and the number of employees, the Anaconda Company payroll is the largest in Silver Bow County. In 1978 mining represented 15 percent of total personal income in Silver Bow County. Wages and salaries of Anaconda Company employees working in Silver Bow County during 1978 amounted to about $34,240,000 (Montana Department of Labor and Industry, written commun., March 20, 1981) while total personal income due to mining (which includes employer contributions to pension plans) was $41,870,000 (table II-16).

3. Fiscal Conditions

As is typically the case in Montana, the Butte-Silver Bow consolidated government is funded primarily with property tax revenues (see fig. II-13). Federal grants and hospital revenues made up most of the remaining money administered by the Butte-Silver Bow consolidated government during 1970-1979. When the revenues shown in fig. II-13 are converted to constant dollars, local government tax revenues decreased by 27 percent between 1970 and 1979. Population also decreased, but at a slower rate and so per capita tax receipts in constant dollars went down by about 23 percent during the same period. This erosion of the local government's revenue source has adversely affected its ability to fund the replacement of plant and equipment (Gary Rowe, Butte-Silver Bow, written commun., April 13, 1981).

Like the Butte-Silver Bow consolidated government, the primary and secondary school systems in the Butte urban area are funded primarily with local taxes. However, in recent years the school system has relied on increasing amounts of State aid through the School Foundation Program. In 1970, about one-third of the general fund receipts of the elementary and high schools in Silver Bow County came from the state. By 1979 this had increased to about 44 percent. School revenue increases have kept pace with inflation and, combined with declining enrollments, has resulted in net increases in constant dollar per capita revenues of about 5 percent per year between 1971 and 1979.

Between 1972 and 1979, the taxable value of the Anaconda Company grew from about $12.3 million to about $17.3 million (Peggy Delaney, Butte-Silver Bow Planning Office, written commun., 1980). The company's taxable value was primarily made up of the value of the mining machinery, the concentrator, and (until 1976) the net proceeds of the operation. The net proceeds was the most variable component of the total taxable value in Silver Bow County (see table II-17), and responsible for most of the variation in the tax rate (mill levy). Depending generally on the amount of net proceeds, which represented from 0 to 28 percent of total taxable value, the Anaconda Company provided between 26 and 45

TABLE II-16.--Personal income in Silver Bow County, 1973-1978 (thousands of dollars)

[Sources: U.S. Department of Commerce, 1980; Montana Department of Community Affairs, written commun., 1981]

ITEM	1973[1]	1974[1]	1975[2]	1976[2]	1977[2]	1978[2]
TOTAL LABOR AND PROPRIETORS INCOME BY PLACE OF WORK[3]						
By type						
Wage and salary disbursements	124,009	136,629	144,323	146,139	154,843	170,976
Other labor income	11,843	11,881	15,175	15,359	16,273	18,265
Proprietors income[4]	11,024	12,188	12,027	12,554	13,352	15,275
Farm	388	155	-224	460	287	799
Non-farm[4]	10,636	12,033	12,251	12,094	13,065	14,476
By industry						
Farm	713	581	164	817	583	1,186
Non-farm	146,163	160,117	171,361	173,235	183,885	203,330
Private	125,986	137,601	144,745	144,908	151,688	167,510
Ag. serv., for., fish., and other[5]	342	354	148	195	(D)	(D)
Mining	47,579	51,052	50,274	40,802	38,773	41,870
Construction	7,568	6,984	5,994	7,262	9,980	12,085
Manufacturing	6,745	7,617	8,145	8,857	9,398	10,127
Nondurable goods	4,666	5,358	5,837	6,599	7,161	7,765
Durable goods	2,079	2,259	2,308	2,258	2,237	2,362
T.P.U.*	9,545	10,690	11,714	12,944	12,943	13,741
Wholesale trade	9,757	11,773	13,683	13,341	12,140	12,916
Retail trade	20,986	23,179	25,118	27,134	28,681	31,202
F.I.R.E.**	4,133	3,808	3,942	4,765	5,762	6,444
Services	19,331	22,144	25,727	29,608	(D)	(D)
Government & government ent.	20,177	22,516	26,616	28,327	32,197	35,820
Federal, civilian	4,316	4,563	5,523	4,685	6,195	6,979
Federal, military	655	682	713	712	635	687
State and local	15,206	17,271	20,380	22,930	25,367	28,154
DERIVATION OF PERSONAL INCOME BY PLACE OF RESIDENCE (SILVER BOW COUNTY)						
Total labor & proprietors income By place of work	146,876	160,698	171,525	174,052	184,468	104,516
Less: personal contributions for social insurance by place of work	9,295	10,322	11,258	11,173	12,149	13,504
Net labor & proprietors income by place of work	137,581	150,376	160,267	162,879	172,319	191,012
Plus: residence adjustment	349	773	515	-579	-650	-1,115
Net labor & proprietors income by place of residence	137,930	151,149	160,782	162,300	171,669	189,897
Plus: dividends, interest and rent[7]	23,235	27,515	29,065	31,535	35,183	39,474
Plus: transfer payments	25,926	29,933	36,735	42,711	44,678	48,045
Personal income by place of residence	187,091	208,597	226,582	236,546	251,530	277,416
Per capita personal income (Dollars)	4,327	4,842	5,275	5,689	6,179	6,964
Total population (Thousands)	43.2	43.1	43.0	41.6	40.7	39.8

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[1] Estimates based on 1967 SIC.

[2] Estimates based on 1972 SIC.

[3] Consists of wage and salary disbursements, other labor income, and proprietors income. Primary source for private non-farm wages: ES-202 covered wages--Montana Employment Security Commission.

[4] Includes the capital consumption adjustment for non-farm proprietors.

[5] Includes wages and salaries of U.S. residents working for international organizations in the U.S.

[7] Includes the capital consumption adjustment for rental income of persons.

(D) Not shown to avoid disclosure of confidential information; data are included in totals.

*Transportation and public utilities.

**Finance, insurance, and real estate.

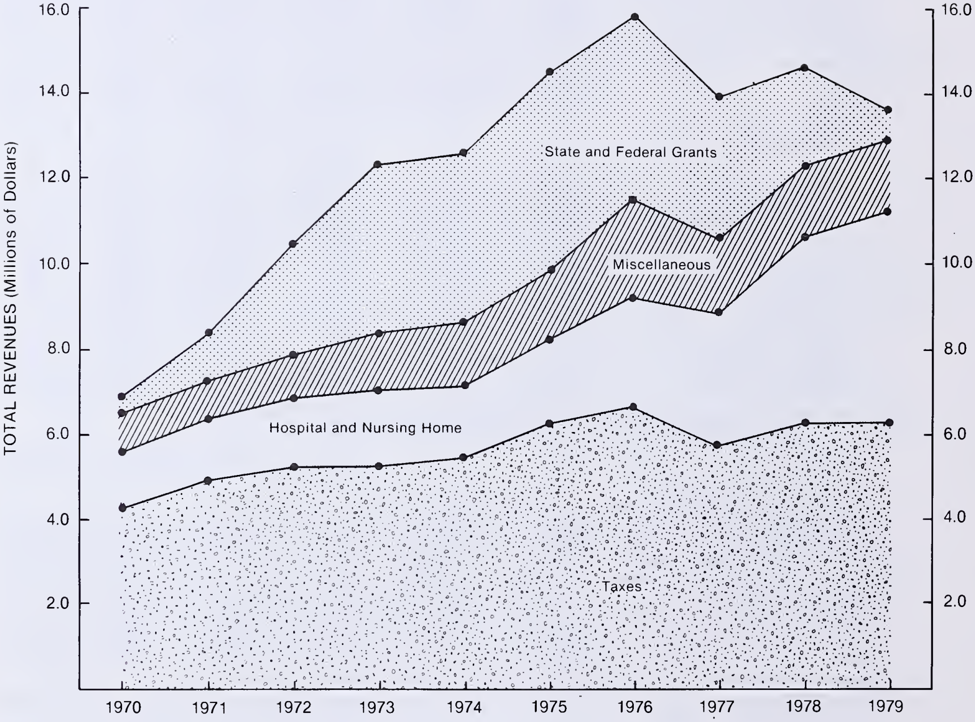

FIGURE II-13.--Sources of revenue of the Butte-Silver Bow consolidated government, 1970-1979.

percent of the county's taxable value during the 1970-76 period. The 1977 Legislative Session changed the method of valuing metal mining property from net proceeds to gross proceeds. The taxable value of metal mine production was changed from 100 percent of net proceeds to 3 percent of gross proceeds. Since that change, Anaconda's production has provided a smaller but less variable proportion of total taxable value in Silver Bow County (see table II-17).

In addition to local property taxes, the Anaconda Company pays several different state taxes. In 1979 the Metalliferous Mines License Tax paid by the Anaconda Company was $1,540,000 and the Resource Indemntiy Trust Tax was $109,000. The Corporation License Tax is not reported separately and so the figure is not available. Total 1979 taxes paid by the Butte operation of the company amounted to $4,550,000 in Silver Bow County and $2,018,000 to the State of Montana.

TABLE II-17.--Summary of Silver Bow County taxable value and total mill levy in the Butte urban area[1], 1970-79

[Dollar figures are in thousands of dollars. Sources: Montana State Board of Equalization, various years; Montana Department of Revenue, various years; and Montana Taxpayers Association, various years.]

	Property other than public utilities		Public utility property (local and allocated)		Net proceeds, royalties and gross proceeds		Total taxable value	Mill levy
	Amount	%	Amount	%	Amount	%		
1970	$33,927	61	$6,485	12	$15,450	28	$55,862	224.40
1971	35,548	66	6,360	12	12,342	23	54,250	242.15
1972	36,773	85	6,700	15	6	0	43,480	274.87
1973	38,439	76	6,727	13	5,230	10	50,396	275.62
1974	41,724	71	7,143	12	9,577	16	58,444	262.12
1975	41,613	65	6,477	10	15,974	25	63,883	282.41
1976	40,942	87	6,250	13	0	0	47,192	314.53
1977	41,066	79	6,388	12	4,511	9	51,964	304.90
1978	45,046	82	6,125	11	3,639	7	54,810	302.97
1979	43,896	82	6,516	12	3,222	6	53,614	339.15

[1] Butte school district (C) 1 total mill levy.

4. Production

Between 1880 and 1979, 9.9 million tons of copper, 700.7 million troy ounces of silver, and 2.9 million troy ounces of gold were taken out of the "richest hill on earth" (Miller, 1973, p. F-2 and table II-18). Since the mid-1970's, the Berkeley mine has almost exclusively produced copper, silver and gold. Since 1961 (the period for which accurate

TABLE II-18.--Selected minerals production summary--Montana total and Anaconda Company, 1961-79

[Source: Montana Department of Revenue, Miscellaneous Tax Division, unpublished report forms--statement of gross yield of mines and metalliferous mines' license tax]

	Copper (short tons)			Gold (troy ounces)			Silver (troy ounces)		
	Montana	Anaconda	%	Montana	Anaconda	%	Montana	Anaconda	%
1961	102,142	102,105	100.0	29,915	18,158	60.7	3,158,014	2,798,482	88.6
1962	91,940	91,920	100.0	17,244	16,638	96.5	3,966,582	3,762,076	94.8
1963	80,085	80,082	100.0	13,787	13,674	99.2	3,781,250	3,745,452	99.1
1964	101,038	101,025	100.0	20,715	20,291	98.0	4,728,327	4,510,474	95.4
1965	117,481	117,476	100.0	19,181	18,712	97.6	4,736,114	4,706,132	99.4
1966	121,793	121,791	100.0	20,767	20,345	98.0	4,730,696	4,697,204	99.3
1967	63,387	63,385	100.0	8,238	8,222	99.8	2,016,520	1,897,375	94.1
1968	69,061	69,061	100.0	10,853	10,839	99.9	1,890,764	1,726,749	91.3
1969	105,281	105,279	100.0	16,246	15,940	98.1	2,681,867	2,583,439	96.3
1970	118,196	118,196	100.0	21,060	20,067	95.3	3,669,855	3,533,000	96.3
1971	88,599	88,599	100.0	15,810	15,133	95.7	2,716,070	2,600,780	95.8
1972	125,607	125,607	100.0	22,660	22,196	98.0	3,235,829	3,090,932	95.5
1973	127,749	127,749	100.0	22,397	20,827	93.0	3,959,641	3,741,617	94.5
1974	132,324	132,324	100.0	25,846	23,935	92.6	3,517,767	3,287,710	93.5
1975	94,145	94,144	100.0	18,541	13,758	74.2	2,601,411	2,179,250	83.8
1976	101,784	101,684	99.9	23,350	21,756	93.2	3,026,402	2,731,754	90.3
1977	83,865	83,716	99.8	21,023	20,626	98.1	2,948,049	2,729,836	92.6
1978	76,533	76,024	99.3	16,437	15,107	91.9	2,588,231	2,072,715	80.1
1979	80,805	80,164	99.2	24,198	21,129	87.3	2,981,501	2,563,909	86.0

annual records are easily available) the Anaconda Company has been the largest metal mine in the state, responsible for virtually all of the copper, 92 percent of the gold, and 94 percent of the silver mined in the state (table II-18). Between 1975 and 1979 the Berkeley Pit's proportion of the total United State's mine production of copper declined from 6.7 percent to 5.1 percent. During the same period the mine produced about 1 percent of total world copper (American Bureau of Metal Statistics, Inc., 1979, p. 9 and table II-18). In recent years the mine has been ranked in the top 5 mines in the country as a silver producer and in the top 15 as a gold producer (U.S. Department of the Interior, 1980, p. 690-691, 837).

K. COMMUNITY SERVICES AND FACILITIES

1. Medical Services

Although medical facilities in Butte-Silver Bow appear adequate in light of declining occupancy rates (Old West Associates, 1978, p. 52), staffing is not adequate. Silver Bow County is designated as medically underserved for primary health care personnel: the population/physician ratio is 698 for Silver Bow County compared to the state average of 398 (Montana Health Systems Agency, 1979, p. 148).

2. Protective Services

Law enforcement in Butte-Silver Bow is generally adequate although 5 more police officers would bring the force up to a medium level of service (Joe Keller, Butte-Silver Bow Undersheriff, oral commun., September 5, 1980). According to Keller, the agency has an adequate number of vehicles and support staff. An additional 20 police officers would bring the police force to 80 officers and provide a high level of service (Intermountain Planners, 1974, p. 32).

Fire protection in Butte is adequate. Response time for fires is good--generally 1 to 3 minutes with 5 minutes the maximum. Facilities and equipment are not adequate: another ladder truck is needed to cover the area, and the pumpers are wearing out owing to high mileage. (William Griffith, Butte-Silver Bow Fire Department, oral commun., September 5, 1980).

3. Education and Libraries

Public and parochial schools in Butte-Silver Bow are adequate for the expected future population of elementary and high school students. Some elementary schools are currently operating below capacity; three public elementary schools have closed since 1977 as a result of declining enrollment (Fred Bull, County Superintendent of Schools, oral commun., November 12, 1980). Total enrollment in the schools has decreased each year since 1974. This downward trend can be explained by the declining population of Butte-Silver Bow and the aging of the population.

Butte Vocational-Technical Center serves both high school and post high-school students. Enrollment has remained at capacity since opening in 1969. The Montana College of Mineral Science and Technology is operating at capacity. Enrollment decreased during the early 1970's, but has grown rapidly since then. The college does not meet the student-faculty ratio of 16-1 adopted by the Montana Board of Regents: in fiscal year 1980 the ratio was 20.5 and is projected to be higher in 1981 (Roy Turley, Acedemic Dean, Montana College of Mineral Science and Technology, oral commun., September 4, 1980).

The Butte-Silver Bow public library is too small to adequately meet the needs of the Butte area, according to standards set by the Public Library Association (PLA)(1962) for cities of Butte's population. The library contains 71,000 volumes--5,000 less than the number the PLA recommends. The library receives 60 periodicals; 200-250 periodicals are recommended for small libraries. The Butte Public Library is open 54 hours each week. These hours are not adequate, according to the head librarian and PLA standards, which recommend 68 hours. The floor space is not adequate and needs to be increased by approximately one-third. A larger staff is needed; thirteen people are employed at the library, eleven work full-time (Francis Wendtland, oral commun., February 23, 1981).

The library at the Montana College of Mineral Science and Technology is also open to the public.

4. Human Services

Human services in Butte-Silver Bow include a senior citizens center and diners' club for people over 60; and a headstart program and daycare center for young children. The Community Preventive Health Clinic sponsors the following programs: Well Child; Women, Infants, and Children, (WIC), Family planning; and Lamaze Prenatal Service. The Human Resources Council administers three youth and one adult employment programs; winterization and energy emergency prevention programs; and the Section 8 Housing Assistance Payments Programs.

5. Water, Sewer, and Solid Waste

Butte's water system, which is owned by the Anaconda Company, is adequate for present needs. The system can supply 30 million gallons of water/day (mgd); winter useage in Butte-Silver Bow averages about 9 mgd; summer usage reaches the capacity of 30 mgd, largely because lawn sprinklers are used. Butte's water comes from three sources: 50 percent from the Big Hole River, 35 percent from Basin Creek Reservoir, and 15 percent from Moulton Reservoir north of Butte (Gary Mannix, Superintendent, Butte Water Company, oral commun. Sept. 5, 1980).

The sewage treatment plant is expected to serve Butte's needs for another 20 years (Old West Associates, 1978). The system operates at its design level of 8 mgd during the summer when water use peaks, but the system can treat as much as 12 mgd (Tom Piercy, chief operator, waste water treatment, Butte-Silver Bow, oral commun., Sept. 5, 1980). The wastewater treatment plant is understaffed. The current staff of 10 is able to provide adequate service, but another 6 workers are needed to perform needed maintenance (Tom Piercy, oral commun., Oct. 10, 1980).

The present sewage collection system is adequate with the exception of some 6-inch lines in outlying areas, which will be replaced with 8-inch lines as necessary. The storm sewer system is adequate in Butte; however, approximately two-thirds of the area outlying do not have storm sewer systems (Bill Mehrens, Maintenance Supervisor, Metro Sewer, oral commun., Sept. 9, 1980).

Solid waste in Butte-Silver Bow is collected by McGree Trucking, a private contractor. The firm has an adequate number of vehicles and staff to serve the approximately 11,000 households in Butte. The garbage is dumped at a landfill south of Butte which is owned by Butte-Silver Bow. The landfill has adequate capacity for the foreseeable future (Tom McGree, McGree Trucking, oral commun., Sept. 9, 1980).

6. Housing

Slightly more than 52 percent of all occupied dwellings in Butte were substandard in 1976, according to criteria established by the local Public Works Department (Miller, 1977). Fifty-six percent of all dwelling units occupied by their owners were substandard. Forty-seven percent of the renters lived in substandard units. This difference is likely not as large in 1980 because many homeowners had hail damage to their roofs just prior to the housing study in 1976. Roof repairs probably removed some dwellings from the substandard category. Although over half of Butte's households live in dwellings classified as substandard, only 8 percent are dissatisfied with their housing. Butte has four large apartment buildings with 364 units for people over 60. The condition of these units is excellent.

7. Transportation

Automobile and truck traffic to and around Butte is carried by two major routes, Interstates 15 and 90, which intersect at Butte. Harrison Avenue, the highest traffic volume street in Butte, is the main thoroughfare conveying traffic between the "flats" and the uptown district. Continental Drive provides access to the Anaconda Company's operation and nearby residential areas. Traffic generally moves well throughout the Butte area (T.A.P., 1980, p. 4).

Rail routes in the Butte area include the Union Pacific; Burlington Northern; Butte, Anaconda and Pacific (BA&P); and the Milwaukee. The Milwaukee was recently closed down and the fate of the BA&P is uncertain.

The BA&P is a wholly owned subsidiary of the Anaconda Company and is dedicated to the transportation of copper concentrates and other company business. When the new lime and drying facilities are constructed at Butte the BA&P could also be closed down. Dry copper concentrates would then be shipped on the Union Pacific to San Diego, and then by ship to Japan for smelting.

Commercial airline service and general aviation is handled at the Bert Mooney-Silver Bow County Airport in the southern part of the Butte urban area. Current plans are that the airport would remain in its present location for at least the next 20 years despite the pressures of business and residential development (T.A.P., 1980, p. 5).

L. LAND USE

More than 90 percent of the land in Silver Bow County, the smallest county in the State is in forest and rangeland use. There is almost no cropland in the county, because the county's economic base has been primarily mining-industrial. The economic trends affecting Silver Bow County over the past 40 years (see Employment) have resulted in a decline of mining jobs and population. As a result, land use changes in the county have been few and relatively small compared to those counties in Montana which grew during the same period. Most of the land use changes that have occured are in or adjacent to Butte. Residential land uses are concentrated in the vicinity of Butte with small amounts in the communities of Melrose, Divide, Ramsey, and Rocker.

The land use pattern in the Butte urban area has changed little in the past 10 years. What change has occurred has mostly been in response to actual or anticipated changes in the Anaconda Company's Berkeley Pit operation. Like Meaderville and Centerville in the 1950's and 60's, the McQueen and Columbia Gardens residential sections and Columbia Gardens recreational area were converted to mining use in the 1970's. During the 1970's, a significant land use issue involved the possible abandonment of Butte's uptown area which was the chief retail and commercial area in Silver Bow County and the surrounding market area. The perception that the Berkeley Pit would soon encroach upon the area, combined with the complex forces that produced the nationwide trend toward suburban shopping malls, induced numerous businesses to move out of Butte's long-established central business district during the 1970's (Butte-Silver Bow County, 1980, p. 21). Despite the announcement by Anaconda in 1977 that the pit would not expand toward the downtown area, this trend continues. Land use in the uptown area has shifted to more office-type commercial use and less retail business (fig. II-14). The movement of retail businesses away from the uptown area resulted in an increase in commercial land use along Harrison Avenue to the south. Much of the new or relocated retail business has developed in a strip-like fashion along Harrison Avenue.

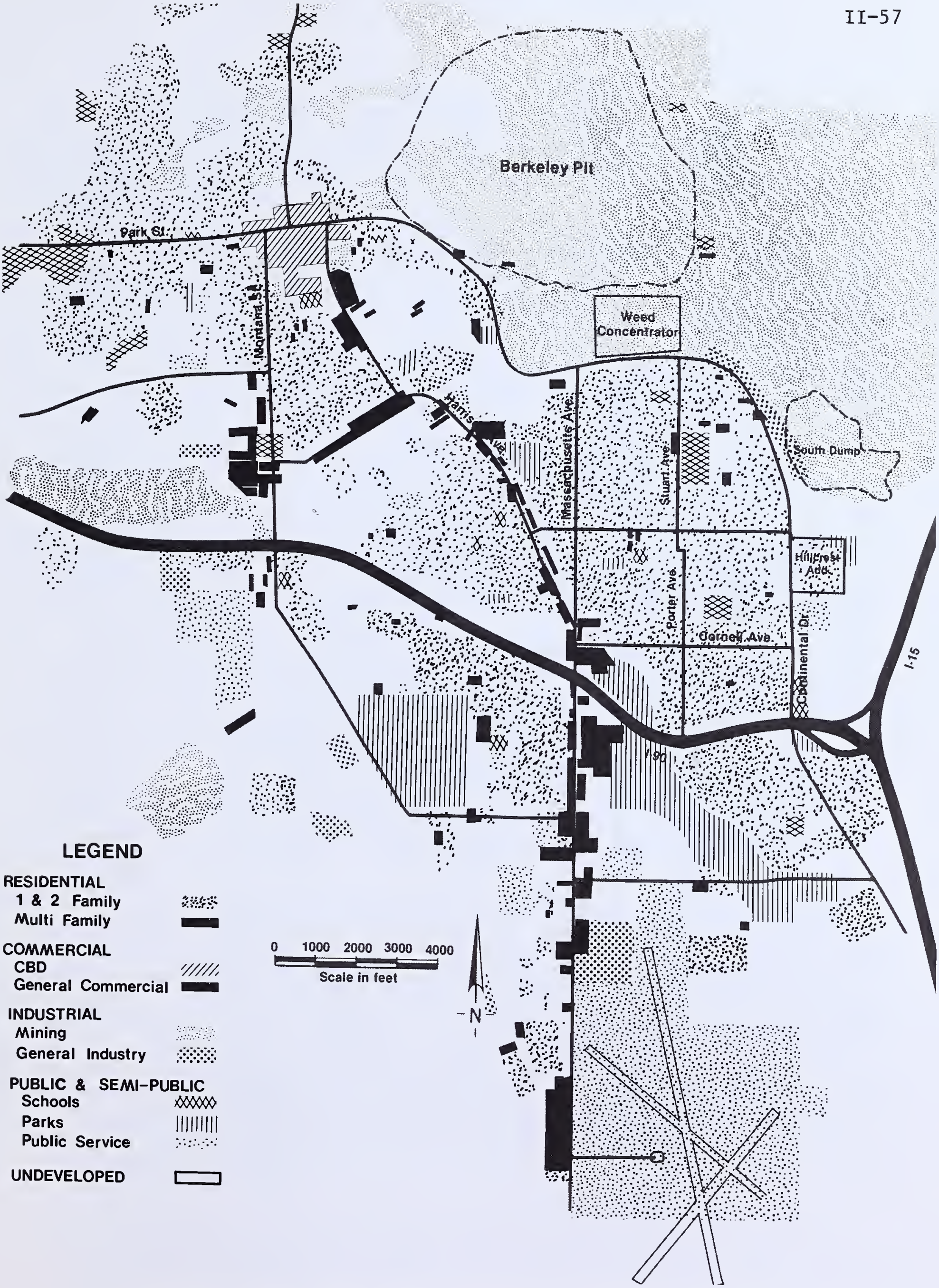

FIGURE II-14.--Land uses in the Butte urban area, 1980.

TABLE II-19.--Land use summary, Anaconda Company's Butte operation

[Figures are in acres. Leaders indicate information not available.
Source: Anaconda Company, written commun., June 12, 1980; October 7, 1980]

	1980		1985		1990		2000	
	Total	Permit area	Total	Permit area	Total	Permit area	Total	Permit area
DISTURBED								
Active mine waste disposal	1,850	86	---	199	---	0	0	0
Associated disturbance[1]	1,423	20	---	35	---	60	380	0
Tailings disposal	736	0	---	0	---	0	0	0
Active pit mining	714	0	---	0	---	22	882	22
Facilities	249	0	---	0	---	0	0	0
Utility corridors	97	35	---	37	---	37	10	0
Reclamation areas	43[2]	13[2]	---	30[2]	---	255	4,558	352
Subtotal	5,069	141	---	271	---	374	5,830	374
UNDISTURBED								
Watershed and wildlife habitat	1,142	285	---	157	---	54	383	54
Residential	2	2	---	0	---	0	0	0
Subtotal	1,144	287	---	157	---	54	383	54
TOTAL	6,213	428	---	428	---	428	6,213	428

[1] Includes former residential, streets, roads, parking lots, railroads, topsoil storage, exploration, and old mining.

[2] Also counted in active mine waste disposal.

Mining acreage has increased to the north and east of Butte and an industrial park has been established near the airport. The Meaderville, McQueen, Centerville, and Columbia Gardens additions, former residential sections of Butte, have become mining-industrial land. Most of the residents of these areas moved to the southern and eastern sections of Butte, an area called "the flats".

The principal land uses in the proposed permit area are mine waste disposal and utility corridors in the disturbed part, and watershed and wildlife habitat in the undisturbed portion (table II-19). The proposed permit area currently represents less than 5 percent of the mine's waste disposal area, and a much smaller proportion of the mine's watershed and wildlife habitat area. Parts of the northern unit of the proposed permit area have been disturbed in the past by mining, road and railroad construction and maintenance, grazing, off-road vehicle recreation, and garbage dumping (Western Technology and Engineering, 1980, p. 4). Until it was abandoned in 1977, U.S. Highway 91 ran through the northern unit. The southern unit of the proposed permit area shows more evidence of disturbance than the northern unit. Past land uses include mining, logging, grazing and smelting. A portion of the Columbia Gardens Addition was in the northeast corner of the unit. Many of the drainages have been used as garbage dumps (Western Technology and Engineering, 1980, p. 7). Parts of the southern unit have also been used for recreation (see Recreation).

Within Butte there has been a trend toward the filling-in of vacant lots in existing residential areas. Some new residential development has occurred to the south of Interstate 90 on both sides of Continental Drive, east of the airport, and on the south near the foothills. New single and multifamily housing in Butte is limited by location and availability. Public and semipublic land uses in Butte have experienced only minor change. Some public parks have been added as have several parcels for school and government. The Butte airport also expanded. Semipublic parcels (churches, cemeteries, etc.) have generally not changed since 1970.

In August 1980, TAP inventoried land use in a 575-acre area near the 158 permit area bounded by Stuart and Porter Avenues on the west, Interstate 90 on the south, and Continental Drive and Custer Avenue on the east and north. About 65 percent of the area is residential. The Hillcrest subdivision, which was built 15-20 years ago, is the area's only residential land use east of Continental Drive. Public and semipublic uses, not including streets and alleys, make up 9 percent of the area. Commercial land use is 1 percent of the total and industrial land use is 0.3 percent. A significant proportion of the total acreage, 24.7 percent, is vacant. Most of the vacant land is concentrated along Continental Drive on the eastern edge of the area and between East Junior High School and Continental Drive.

Few changes in land use have occured in this area in the past 20 years. The most significant change has been the gradual conversion of vacant land to residential use and the addition of six commercial parcels.

M. RECREATION

Urban recreation resources in Butte are not adequate for the existing population (Butte-Silver Bow Planning Board, 1981). The Butte-Silver Bow Recreation Department sponsors a wide variety of activities, including programs for developmentally disabled children; however, more neighborhood parks are needed, particularly in the uptown area. More open space is needed for ball practice, walking, bicycling, picnicking and passive enjoyment of the natural landscape. More facilities are also needed, such as playground equipment, skating rinks, wading pools, and picnic tables, etc.

Residents of Butte have good access to outdoor recreation on nearby National Forests land and other public and private lands. The U.S. Forest Service manages several areas in the Deerlodge National Forest which are used by local people for recreation. Major uses of the National Forest lands include hunting, motorcycling, cross-country skiing, hiking, four-wheel driving, and other forms of dispersed recreation. Local people are the primary recreationists in these areas; the level of recreational use varies among the areas but does not approach capacity in any of them (Ron Hanson, Deerlodge National Forest, oral commun., January 15, 1981).

The U.S. Bureau of Land Management manages four recreational areas in Silver Bow County: Humbug Spires; Soap Gulch and Maiden Rock; Jimmy New Creeks; and Dickie Hills. These areas are prime hunting areas, the latter two are in Elk and Deer Hunting District no. 319 which receives the highest elk hunting use in the state. Eighty percent or more of this use is from the Butte-Anaconda area (Mike Frisina, Montana Department of Fish, Wildlife and Parks, oral commun., February 23, 1981). All four areas are also used for hiking, wood gathering and sightseeing; the Humbug Spires receives some use for rock climbing.

There are seven ski areas within a 125-mile radius of Butte, and numerous rivers, streams, and lakes within a 50-mile radius. The Fairmont Hot Springs Resort, 12 miles west of Butte, provides swimming, golfing, and horseback riding. Thompson Park, located partially on the Deerlodge National Forest, is used heavily for picnicking, sledding, and cross-country skiing. This area is managed jointly by the U.S. Forest Service and Butte-Silver Bow.

Entertainment in Butte includes three movie theaters, snowmobile, stock car, and motorcycle races, and athletic events. Bars and taverns are a significant mode of entertainment in Butte (Montana Energy and MHD Research and Development Facility, 1979, p. 36). The county has 87 all-beverage liquor licenses compared to its quota of 18. Butte has a high number of licenses because they have been renewed annually while the population of Butte has declined.

There are four museums open to the public, one of which is listed on the National Register of Historic Places. The area also has two local theater groups, art shows, and a film society.

Prior to dumping, the proposed permit area was heavily used by motorcyclists, joggers, and hikers without permission of the Anaconda Company. This use was reduced but not eliminated in 1980 when a fence was built along the area's western and southern boundaries (Rudio and Associates, 1980).

N. CULTURAL RESOURCES

Seventeen historical sites were located by an intensive field inventory of the proposed permit area (Steere, 1980). No archeological sites were found, owing to previous mining disturbances. The historic site types include: 10 mining, 2 transportation, 1 commercial art, 1 residence, 1 power utility line, 1 dump, and 1 recreation and park site. The historic mining sites consist of several prospect holes, a concrete slab, two mine dumps, and a rock pier. The historic transportation sites are a railroad tunnel and a concrete bridge. The historic commercial art consists of two large granite boulders with handpainted advertising on them. The historic residence consists of a concrete foundation, a brick root cellar, and a collapsed shed. The historic dump is an automobile graveyard. The historic recreation and park site is the site of Columbia Gardens which has been destroyed (Steere, 1980). None of the sites meet the criteria for nomination to the National Register of Historic Places (Steere, 1980).

Mining claims which date from the late 1870's through the early decades of the 1900's cover the entire project area. Most of these claims were patented but very few were worked and fewer still had extensive production.

Probably the most important historical site in the Hillcrest Project Area--Columbia Gardens--no longer exists. The Gardens was established in 1899 by W. A. Clark and bought by the Anaconda Company in the 1920's. Columbia Gardens contained an amusement park, an arcade, a dance hall, elaborate flower gardens, picnic grounds, a pond, baseball fields, and football fields (Steere, 1980). It was the major recreation area for the people of Butte until the area closed in 1973 due to mining. The area was used as a dump for overburden from the Continental East Pit.

O. ESTHETICS

1. Visual Resources

Anaconda's Butte operation is the single most visible industrial sight in the Butte area. The Berkeley Pit highwall, the leach dumps, the concentrator, the Continental East Pit highwall, and the existing south dump can be seen from most of the residential areas of Butte. The brown, grey, and pink of the highwalls and dumps contrasts with the green of the relatively undisturbed hillslope vegetation north and east of the mine. The primarily horizontal lines of the pit benches and dump tops contrast with the irregular lines of the slopes in the background.

Of Anaconda's Butte operations, the existing south dump is the dominant visual feature seen from the Hillcrest subdivision, nearby residential areas, and from Interstate 15 about 1 mile north of its interchange with Interstate 90. The dump dominates the view north from Hillcrest: the flat top of the dump cuts across the skyline and background buttes, and the face of the dump has little topographic, textural, and color variation. Figure II-15 depicts the south dump in relation to nearby mining and residential areas. From elsewhere in Butte--particularly from the "flats" and the uptown area--the pit highwall, leach dumps, and concentrator are more evident than the south dump. This is so because the west face of the dump has a temporary vegetation cover that to some extent blends with the slopes of East Ridge in the background, and because the dump does not project far above trees and buildings when viewed from the flats south of I-90. The pit and other dumps are not vegetated and stand out from the background.

Residents surveyed in a study area near the south dump (see Social Conditions) showed some concern about the appearance of the dump. Fourteen percent of those interviewed in the subarea closer to the dump felt that it had a negative esthetic impact; 3 percent felt that the dump had improved the looks of the area (many of the drainages had been used as garbage dumps in the past). In the subarea farther from the dump, 8 percent felt that it had a negative esthetic impact; none felt that it had a positive effect.

2. Noise

Sound pressure levels (SPL) were measured at 3 locations by the Anaconda Company and at 4 locations by the Montana Department of Health and Environmental Sciences (DHES). Results are on file at the Montana Department of State Lands. Only the Hillcrest site results are discussed here, because the Anaconda Company Hillcrest site is close to the permit area and the data collected at that site are the most complete.

The major sources of noise in the Butte area are associated with transportation: railroads, airplanes, and vehicles, and with the Anaconda Company mining operation. The L_{dn} sound level (see Appendix O-1 for a discussion of acoustic nomenclature) at the Hillcrest site during normal mine operation (without the south dump construction) is about 57dB(A). During the July 1977 strike, this level decreased to 55dB(A) (table II-20). Therefore, the entire Anaconda operation contributes about 2 dB(A) to the background sound level at Butte. Because the decibel scale is logarithmic, this 2dB(A) increase would denote about a 15 percent increase in the sound level. These background sound levels are typical of a suburban residential area at the outskirts of a city (Eldred, 1974).

The 57dB(A) level is well below the L_{dn} 70dB(A) level that causes hearing loss with prolonged exposure (EPA,1974). It has been difficult to document any effect of low level noise [55-65 dB(A)] on mental or physical health (Steven Keele, University of Oregon, written commun., June 5, 1980). At 57dB(A) there may be occasional interference with

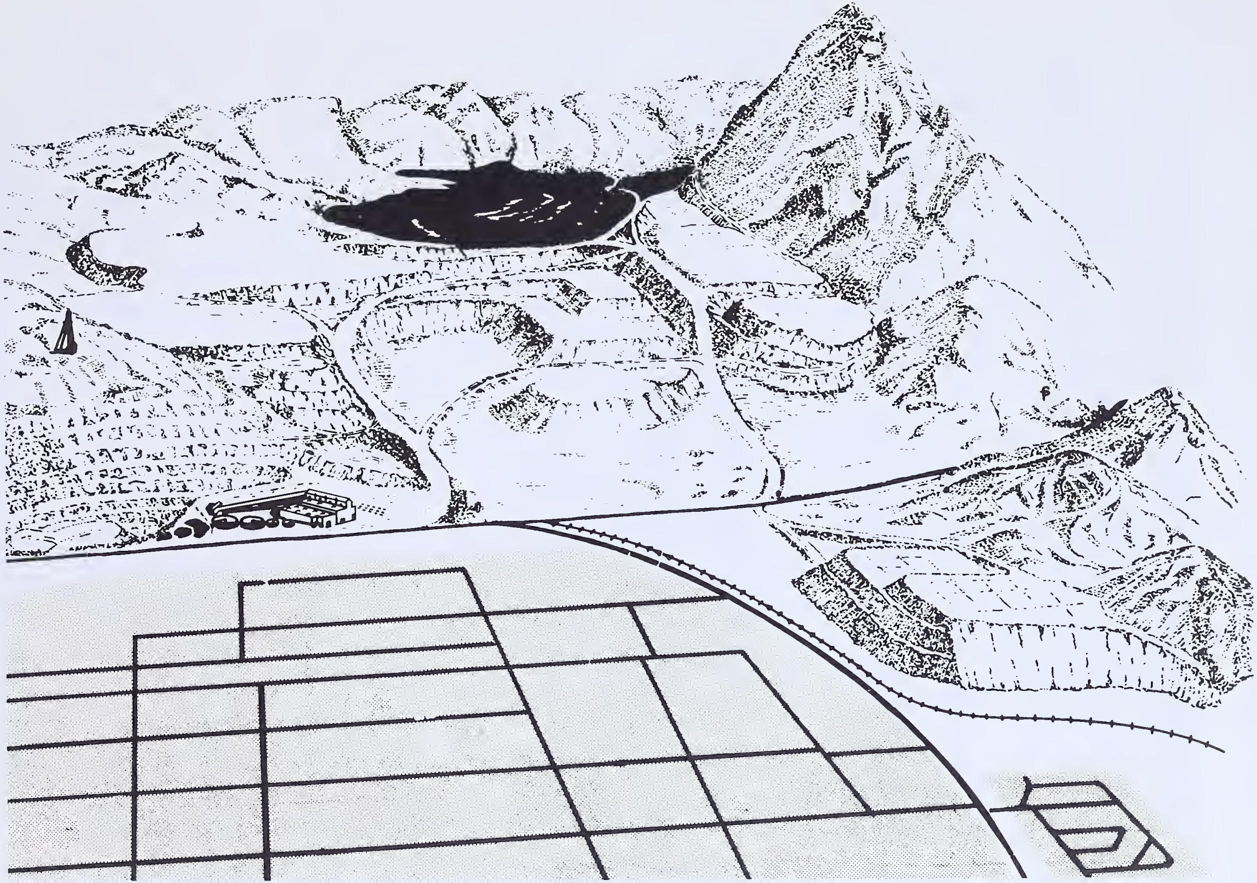

FIGURE II-15.--Oblique view of the Anaconda Copper Company's Butte operations (artist's depiction).

normal outdoor conversation in the Hillcrest area (table II-21). There would be little, if any, interference with indoor activity at those levels (EPA, 1974). However, according to the EPA (1973), 17 percent of the people exposed to a sound level of L_{dn} 55dB(A) would be highly annoyed with 1 percent of those exposed registering complaints. At L_{dn} 60 dB(A), 23 percent could be expected to be highly annoyed, and 2 percent would register complaints.

Noise was mentioned as a problem from previous south dump operations by 188 heads of households--17.4 percent of those in a study area near the dump (see Social Conditions). However, monitoring data indicate that noise did not increase significantly during dumping (table II-20). No complaints about noise were registered with the office of the Chief Executive of Butte-Silver Bow during that period.

TABLE II-20.--Statistical sound levels at the Hillcrest Station

[See Appendix O-1 for an explanation of these levels and Federal guidelines. Day is defined as the period from 7:00 a.m. to 7:00 p.m; night is defined as the period 7:00 p.m. to 7:00 a.m.]

	L_{90}		L_{50}		L_{10}		L_{eq}		L_{dn}
Time Period	Day	Night	Day	Night	Day	Night	Day	Night	
Before Dump Construction 7-25-76 to 8-12-76	43	43	46	46	51	50	---	---	---
During Dumping 8-29-76 to 6-30-77	45	43	50	47	55	52	56	51	58
Strike July 1977	41	38	46	41	52	47	55	47	55
After Cessation of Dumping 5-1-78 to 6-1-78	42	42	48	46	55	52	54	51	57
5-1-79 to 7-1-79	---	---	47	49	56	53	55	52	59
4-14-80 to 5-13-80	---	---	47	47	53	51	54	51	58

TABLE II-21.--Noise limits required to protect public health and welfare with an adequate margin of safety

[Source: U.S. Environmental Protection Agency, 1974]

Effect	Level	Area
Hearing loss	$L_{eq(24)} < 70$ dB	All areas
Outdoor activity	$L_{dn} < 55$ dB	Outdoors where quiet is a basis for use.
	$L_{eq(24)} < 55$ dB	Outdoor areas where people spend limited time, such as school yards and playgrounds
Indoor activity interference and annoyance	$L_{dn} < 45$ dB	Indoor residential areas.
	$L_{eq(24)} < 45$ dB	Other indoor areas with human activities such as schools, etc.

$L_{eq(24)}$ represents the sound energy averaged over a 24-hour period.
L_{dn} represents the L_{eq} with 10 dB nighttime weighting.

CHAPTER III

IMPACTS OF THE COMPANY'S PROPOSAL

A.-D. RECLAMATION

1. General Summary

Reclamation of the waste dumps would be reasonably successful as long as the company maintains the dump slopes. Once intensive maintenance of the slopes ended (after approximately 20 years), moderate to localized severe erosion and revegetation problems are expected to occur, especially on the south and west slopes. The south and west faces of the dumps are expected to support sparse vegetative cover due to droughtiness and anticipated erosion problems. "Slight" to "moderate" amounts of gullying are expected to completely eliminate vegetation in localized areas of the south and west dump slopes and may eventually cause water quality problems (see Hydrology). Although wildlife diversity is expected to be less on the reclaimed dumps than existed prior to dump construction, overall wildlife impacts are not expected to be significant.

The reclamation plan proposed by the company states that the final vegetation establishment on the dump slopes would be of similar cover density as the vegetation found on typical natural slopes in the area having similar steepness, aspect and type of vegetation. The proposed plan additionally states that erosion rates on the dump slopes would be of similar magnitude as erosion rates on typical natural slopes in the area having similar steepness and aspect.

A. GEOMORPHOLOGY

1. Summary

While the company is intensively maintaining the dump slopes, erosion rates are expected to be about 2-4 tons/acre/year--about the rate at which soil would be formed. As a result, overall vegetation establishment would be moderate to good for about 20 years after dumping began (see Vegetation). After the erosion control berms filled with sediment and the terraces were regraded (see chapter I, Summary of Reclamation Plan), erosion rates are expected to increase by as much as fourfold (south and west slopes of the two dumps) owing to sheet and rill erosion. Slight-to-moderate amounts gullying would also occur causing locally severe vegetative impacts.*

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*Sheet erosion is erosion caused by raindrop impact and unconcentrated surface runoff. Rills are distinct channels less than 1 foot deep; gullies are channels deeper than 1 foot. Both caused by concentrated runoff.

The company would probably have difficulty meeting its objective of holding erosion to levels that could be expected on typical natural slopes in the area having similar steepness and aspect. Vegetation would be removed where gullies formed, and vegetative productivity would be reduced by sheet and rill erosion between the gullies. Sediment eroded from the dump faces would bury existing vegetation close to the dump and reduce vegetative productivity farther from the dump. In the long term (100's to 1,000's of years), the waste rock core of the dump would be exposed, and the eroded sediment could fill in the water diversion ditches around the base of the dump. This may adversely affect off-site surface water quality (see Hydrology).

Due to the technical nature and depth of analysis required to elevate the erosion potential on the dumps, the discussion contained in this document is a generalized summary of findings. A more technical analysis has been developed and is available upon request as an open file report from the Department of State Lands in Helena

2. Short term impacts

While the company maintained the berms and terraces (about 20 years after dumping begins), erosion rates on the dump faces would be fairly low--less than 5 tons/acre/year, based on the universal soil loss equation (U.S. Department of Agriculture--Soil Conservation Service and U.S. Environmental Protection Agency, 1977). This rate of erosion would be close to the expected rate of soil formation on the dump faces (fig. III-1).

Localized gullies may form if runoff water overtopped the berms or terraces. The company would probably be able to maintain the terraces and avoid serious gully formation. The terraces would be capable of handling runoff generated by a fairly large storm. Heavy equipment would be able to operate on the terraces making repairs relatively easy. The berms, however, would be less capable of handling runoff from the dump slopes and would be less accessible to maintenance equipment. As a result, during severe storms, collected runoff water in the berms would probably overtop the lip of the berm sending concentrated runoff downslope. Where one berm failed, the berms below would likely fail, releasing collected water and increasing gullying downslope. Although berm failures would be difficult to prevent, the company could fill in and revegetate the gullies after the storm.

Sediment eroded from the dump would have negligible adverse effects during the short term, because the company's runoff diversion system would collect the runoff and direct it to a sedimentation pond or the Berkeley Pit (see Hydrology).

3. Middle term effects (20-100 years after dumping begins)

Once the company stopped maintaining the dump faces, the terraces and berms would no longer control runoff water. As a result, erosion rates would increase significantly, especially on the longer, drier south

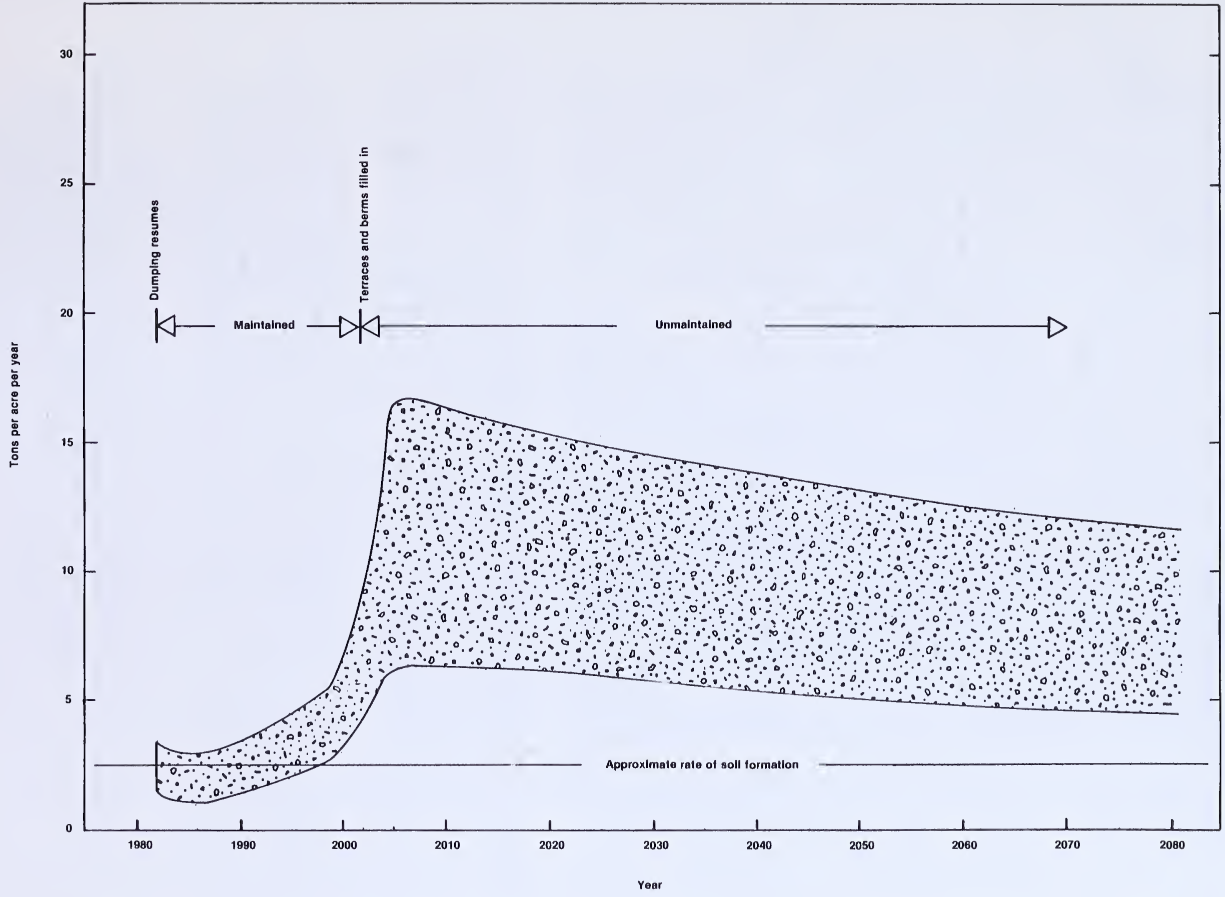


FIGURE III-1.--Sediment loss rates due to sheet and rill erosion on the south face of the proposed south dump. The upper limit was estimated using 40 percent ground cover and 25 percent canopy cover. The lower limit was estimated using 60 percent ground cover and 40 percent canopy cover. Gully erosion is not included because the amount could not be estimated, but would add to the total sediment loss rate.

and west slopes of the two dumps. The north and east slopes would have better vegetative success and therefore lower rates of erosion. The top of the dumps will have moderate vegetative cover at best, but since they will be almost flat, erosion is not expected to be a problem on the dump tops. Since erosion rates would be highest and reclamation success lowest on the south and west slopes of the dumps the following discussion primarily focuses the south and west slopes of the two dumps.

The company proposes to fill in the erosion control terraces, at which time erosion rates are expected increase on all dump slopes. Erosion rates on a majority of the north and east facing slopes would probably not increase appreciably once the terraces are filled. The reason for this is the length of the slopes would increase only slightly and only in a few places after the terraces are filled. On the other hand, erosion rates on the south and west facing slopes could increase significantly; increasing from 2-4 tons/acre/year to 10-15 tons/acre/year (see fig. III-1). Erosion rates of 10-15 tons/acre/year, although not uncommon on heavily grazed rangeland in Montana (Brian Sindelar, Montana State University, oral commun., February, 1980), would adversely affect vegetation. This is especially true on the south and west slopes of the dump where vegetation may only be moderately successful even if there were no erosion problems (see vegetation).

Erosion rates of 10-15 tons/acre/year (south and west slopes) would gradually remove the soil on the dump slopes except where anchored by vegetation. Eventually the vegetation would be left standing above the eroded bare topsoil areas between the vegetated clumps. This phenomenon is called vegetative pedestaling. Eventually roots of some of the plants would be exposed, stressing or even killing the plants (see vegetation).

Erosion on the south and west slopes of the dump would also remove the Columbia Gardens topsoil which the company plans to place on these critical slopes to increase vegetative success. Erosion rates of 10 tons/acre/year would entirely remove the topsoil within 100 years. The topsoil would initially be only 4-5 inches deep and as it is lost, vegetation productivity would be reduced. Erosion on the south and west dump slopes would limit vegetative density to relatively low levels (see vegetation).

Erosion would also expose pebbles and cobbles contained within the alluvium and topsoil. The exposed pebbles would form a protective coating on the surface of the dumps (pebble armoring) reducing sheet and rill erosion (fig. III-1). The erosion rates on the south and west faces of these dumps would probably drop to around 10 tons/acre/year or slightly lower in about 100 years, but once the topsoil is lost another jump in erosion rates could be expected (see Long Term).

Neither pebble armoring nor vegetative cover would stop gullies from forming on the dump faces. Once the company stopped intensive management of the slopes, gullies would begin forming especially on the long, dry south and west slopes. Gullies would probably be spaced more than 100 feet apart near the top of the south and west dump faces. Greater than 100 foot spacing between gullies is termed "slight" gully erosion by

Dunne and Leopold (1978, p. 532). Gullies would increase in size and density downslope, possibly branching apart at the filled-in terraces. The spacing between gullies would probably be less than 100 feet on the lower half of the dump faces--termed "moderate" gully erosion by Dunne and Leopold.

These gully erosion estimates are based on experience with reclaimed mine lands at Colstrip, Montana, which also has a semiarid climate. At Colstrip, soils with a sandy texture similar to the alluvium at Butte were susceptible to gully formation on 10-20 percent slopes. The dump slopes at Butte would be 40 percent, over twice as steep as the threshold at which gullies formed at Colstrip. At present no accurate method is available to determine where and how severe gullies will be. Based upon experience at Colstrip, which is similar enough for broad comparative purposes, the predicted level of gully development is considered reasonable. The north and east slopes may develop a few gullies, but not nearly as many as the long and drier south and west slopes of the two dumps.

Motorcycles will be a serious problem on any reclamation attempted on the rather steep slopes of the dumps. Motorcycles have been observed frequenting the existing dumps. Tracks left by cycles climbing the reclaimed dump slopes would form areas where water could concentrate. After the company stops maintaining the dump slopes, disturbances caused by cyclists would not be fixed and qullies are expected to form as a result. Cyclists who trespass and climb the dumps have been impossible to stop in the past and, therefore, are expected to cause similar problems on future reclamation sites. The long south and west slopes will be the worse problem areas if cyclists climb them.

Vegetation would be removed where the gullies formed; in addition, soil and alluvium a few feet from the gullies would be dried out, reducing vegetative productivity. Gully erosion would also increase the rate of sediment loss from the entire dump. Although the amount of sediment lost due to gullying cannot be quantified, it would probably be less than the amount lost due to sheet and rill erosion (Dunne and Leopold, 1978, p. 516).

Coarser sediment eroded from the dump would be deposited near the base of the dump, where it would bury vegetation. The remaining sediment would most likely be directed into the Berkeley Pit by the runoff diversion system and would not present a water quality problem. If the diversion system were not maintained, it could possibly fill with sediment to the point where runoff would reach offsite waterways (see Hydrology). This appears unlikely during the first 100 years.

Anaconda's monitoring program would be continued after the berms and terraces are filled and until the company petitions for bond release. If this is the case, then the erosion monitoring program would be a valuable mitigating technique that could lead to appropriate changes in reclamation methods if necessary.

4. Long Term Effects (over 100 years after dumping begins)

Continued gully erosion would begin to expose isolated portions of the waste rock core of the dump possibly within centuries. The gullies could reach their most intricate pattern of development at that time. Once the gullies reached the more resistant waste rock, the downward cutting would proceed much more slowly. As the waste rock was exposed, runoff water that came in contact with it would be contaminated (see Hydrology). The south and west faces of the dumps would be the primary area of gullying and would therefore be the primary source of the water quality problems from runoff water the dumps. Should the proposed diversion systems fail, the intermittent streams that could begin to eat away at the dump would constitute an even more serious water quality problem than the gullies (see Hydrology).

The company proposes to build a berm at the crest of the dumps to prevent water that collects on the top of the dump from spilling over and running down the dump faces. This berm, if constructed of alluvium, could eventually erode away, allowing water collected on the top of the dumps to add to runoff on the faces of the dumps. Gully erosion would then be much worse. The company could be required to construct the berm with an erosion-resistant material (such as waste rock) that would protect the crest from breaching (see chapter IV, Technological Alternatives).

On the south and west slopes, sheet and rill erosion, after a century would probably drop to below 10 tons/acre/year as a result of pebble armoring. The Company proposes to put topsoil on top of the alluvium in order to increase vegetative productivity on the critical south and west slopes of the dumps. Once this topsoil was lost, the vegetation cover would be less vigorous. Erosion rates would increase by more than 13 percent just due to the textural change from topsoil to alluvium; the alluvium would have less organic matter. The loss of organic matter would also reduce vegetative productivity which would cause erosion rates to increase (see Vegetation). How much of an increase in erosion rates would occur due to both the textural change and the reduction in vegetation is difficult to estimate. A 25 percent increase would appear to be reasonable.

Erosion rates would probably remain above 5 tons/acre/year for centuries. Erosion rates would most likely always remain higher than the rate of soil formation even with pebble armoring. As a result, in several thousand years the entire waste rock core of the dumps would be exposed. The bare waste rock would severely limit vegetation (see Vegetation) and could cause serious water quality problems (see Hydrology).

In the long term, natural erosion processes would lower the angle of the dump slopes and modify their shape to a geomorphically stable configuration. The waste rock dumps would be mounds of sandy-textured alluvium with a waste rock core. It is highly unlikely that such geomorphic structures--solid rock covered with 10-20 feet of unconsolidated material at 21-24°--would be found in nature. Hill or mountain sides as steep or steeper than the proposed dumps with good vegetative cover may be found.

However, brush, trees, boulders, and bedrock tend to anchor sandy-textured material in natural areas, whereas the waste dump, especially the south and west aspects, would not have these slope stabilizing features. After thousands of years, the waste rock core of the dumps will be entirely exposed and little could be done, short of lowering the dump slope angles, to retard this process (see Technological Alternatives).

B. SOILS AND ALLUVIUM

Anaconda proposes to veneer most of the dump surfaces with alluvium from the East Berkeley pushbacks and the Southeast Berkeley Pit, because the volume of soil that would be stripped and stockpiled as mining progressed would not provide sufficient cover for the dump areas.

1. Toxic Metals

Tables III-1 and III-2 list soil and alluvium properties that exceed State suspect levels. These levels indicate that localized plant toxicity problems may occur if soils or alluvium with these properties are placed at the surface or in the vegetative rooting zone. The data presented in table III-1 represents roughly 17 percent of all soil samples taken relative to this project. The data presented in table III-2 represents roughly 35 percent of all alluvium samples taken.

At acid pH values (values less than the neutral pH of 7.0), the metals listed in the tables are generally more available for uptake by plants and therefore could be expected to create plant problems. In contrast, for metal values that exceed State suspect levels but have a corresponding alkaline pH values (greater than 7.0), problems with plant toxicity would be minimal or nonexistent because the metals would be unavailable for uptake by plants.

The soil and alluvium samples obtained for the chemical analyses were usually taken in place under "natural" conditions. Handling and stockpiling salvaged soil and overburden (alluvial) material changes their chemical, physical, and biological properties (Miller and Cameron, 1976; Curry, 1975). Anaconda would move and stockpile soil and alluvium until the waste dump is constructed and reclamation began in the mid-1980's. Many of the soil and alluvium layers that have elevated metal concentrations may be diluted during handling. However, pockets of undesirable chemicals may be exposed to weathering during the process, accelerating the breakdown of potentially toxic material.

Localized failures in reclamation are likely to occur where soil and alluvial material containing toxic levels of certain metals is distributed at or near the dump surfaces, and where corresponding pH values are conducive to uptake of those metals by plants. Such areas could be about 0.1 acres to a few acres in size. Such failures could occur almost immediately or a number of years after vegetation is established. The latter situation

TABLE III-1.--Soils properties excedding State suspect levels (---) indicates no name given

Permit Area	Sample Location Number	Series Name[1]	Depth (inches)	Property	pH	Observed Value (ppm)[2]	State Suspect Level (ppm)[2]
158	14A	Koy	0-4	Copper	4.7	103	>40
				Cadmium	"	0.61	>0.5
158	16A	Koy	0-3	Cadmium	5.5	0.96	>0.5
158	6A	Nib	0-8	Copper	5.6	95.1	>40
				Cadmium	"	0.83	>0.5
158	6B	Nib	0-6	Copper	"	75.8	>40
158	9A	Tet	0-3	Zinc	5.6	286	>40
				Copper	"	136	>40
				Cadmium	"	3.45	>0.5
				Nickel	"	1.71	>1.0
158	11A	Tet	0-6	Zinc	5.3	75	>40
				Copper	"	50.5	>40
				Cadmium	"	1.43	>0.5
158	11B	Tet	0-3	Copper	5.8	66.4	>40
			3-9	Zinc	5.7	91.4	>40
				Nickel	"	2.23	>1.0
30A	S-5	---	0-6	Copper	5.3	98.1	>40
			6-12	Manganese	5.8	83.3	>60
30A	S-6	---	0-6	Copper	5.1	136	>40
				Cadmium	"	3.04	>0.5
			6-12	Manganese	5.6	113	>60
30A	S-7	---	0-6	Copper	5.9	194	>40
30A	S-8	---	0-6	Copper	4.8	50.8	>40
30A	S-10	---	6-12	Mercury	5.7	0.655	>0.5
				Copper	"	231	>40
			12-18	Copper	5.4	79.5	>40
			18-36	Manganese	5.5	85.6	>60
				Copper	"	67.3	>40
30A	S-14	---	12-18	Copper	5.6	109	>40
				Cadmium	"	0.68	>0.5
30A	S-15	---	0-6	Copper	5.1	147	>40
			6-12	Copper	"	162	>40
30A	S-17	---	0-6	Copper	5.9	84.6	>40

[1] Soils series names are not official names designated by the U.S. Soil Conservation Service. They are for reference purposes only.

[2] Parts per million.

TABLE III-2.--Alluvium properties exceeding State suspect levels

Sample Location Number[1]	Property	pH	Observed Value (ppm)[2]	State Suspect Level (ppm)[2]
Sump 2	Copper	6.1	125	>40
	Cadmium	6.1	0.99	>0.5
#2	Manganese	5.9	168	>60
#5	Zinc	4.9	108	>40
	Manganese	4.9	137	>60
	Copper	4.9	68.9	>40
	Cadmium	4.9	0.94	>0.5
A-6	Zinc	6.1	110	>40
	Manganese	6.1	143	>60
	Copper	6.1	192	>40
A-15	Lead	7.5	34.5	>20 (pH>6)
B-1	Manganese	5.2	332	>60
B-2	Manganese	4.8	330	>60
B-3	Manganese	5.2	162	>60
	Copper	5.2	71.9	>40
B-4	Manganese	5.3	143	>60
E-2	Nickel	5.8	8.52	>1.0
G-2	Lead	6.7	22.5	>20 (pH>6)

[1] All samples were taken in permit area 30 or 30A.

[2] Parts per million.

could happen if acid-generating materials (such as pyrite) broke down with time and decreased the pH (increased acidity) of the growth medium. Such an occurrence would make available any potentially toxic metals within ranges that were previously unavailable because of a higher (more alkaline) pH.

Analysis of the soils and alluvium revealed low total sulfur content and therefore, low concentrations of pyritic material compared to ore or waste rock. However, even low concentrations of pyritic material may, upon weathering, create acid conditions that would increase the availability of the metals on a localized basis. Based on findings discussed by Grube and others (1973) and the average total sulfur values from analysis of the samples (assuming complete oxidation of pyrites), the application of approximately 1 ton/acre of lime (calcium carbonate) would be sufficient to create neutral or near-neutral conditions in the surface zone of the soil and alluvium. This would reduce localized failures due to metal toxicity for the short term (see chapter IV, Technological Alternatives).

Because of the low nutrient adsorption capacity of the soils and alluvium (ability of the soils and alluvium to attract nutrients), the lime would eventually leach out of the rooting zone, perhaps within a few decades. When this happened, localized vegetation failures could occur as any remaining pyrites oxidized and formed sulfuric acid.

2. Moisture

The low moisture-holding capacity of the soil and alluvium would inhibit vegetation growth. This would moderately to severely limit moisture available for plant growth during reclamation (see Vegetation).

Approximately half of the soil samples and a third of the alluvium samples tested had water saturation percentages of less than 30 percent, with an average for all soil and alluvium samples of roughly 32 percent. This indicates that the moisture retention capacity of the materials tested is poor to fair at best (Schafer, 1979). The low moisture retention capcity can be attributed to the coarse texture of the soil and alluvial material--approximately 90 percent of all the material tested had textures of sandy loam or coarser. In addition, the alluvial material contains no organic matter, which if present, increases water retention capacity. The soils, with their thin surface horizons and sparse vegetative cover, are very low in organic matter. Also, potential evapotranspiration (moisture loss from plant cells by evaporation) exceeds precipitation during the growing season, and a net moisture deficit occurs (Hydrometrics, 1980).

3. Nutrients

Preliminary analyses of the soil and alluvial material indicate that these materials are low in the major nutrients necessary for optimum plant growth. An exception to this is potassium which was found to be high in most cases. Elevated amounts of potassium in the materials is probably a result of the continual breakdown of the high concentrations of mica and other potassium-rich minerals in the area.

The texture and organic matter content of the soil or alluvial material would affect its ability to attract and store mineral nutrients. Generally, the coarser (sandier) the material, the less fertile it is because it lacks the colloidal clay necessary for high nutrient-adsorbing capacity. Similarly, the less organic matter present, the lower the fertility of the material, since organic matter also has a high nutrient-adsorption capacity.

After the soil and alluvial material is redistributed on the dump surfaces, sampling and subsequent nutrient analyses would be conducted to determine what elements are needed and at what rate. Because of the sandy nature of the soils and alluvium and the lack of appreciable organic matter, a very intensive fertilization program would be needed. After the first few growing seasons, most of the applied nutrients not utilized by the plants would probably be leached out of the root zone because of the low nutrient-adsorption capacity of the materials. The company could be required to add supplemental fertilizer as needed until the vegetation is well established and organic matter started to increase in the soil and alluvial material (see chapter IV, Technological Alternatives).

4. Crusting

Most of the dump surfaces would be veneered only with alluvium which tends to form hard surface crusts 1/2 inch to 6 inches thick when dried. This could impede seedling emergence under some conditions. If sufficient moisture were present for the seeds to germinate, but the surface dried out before the seedlings reached the surface, the resulting hard crust would prevent emergence of the seedlings. If the alluvium remainded moist after germination, the crust would not form; if the surface dried out after some of the seedlings emerged, the crust would probably crack and weaken, providing openings through which seedlings could grow (Edwards, 1977).

5. Organic Matter

The surface crusting of the alluvial material is a physical problem caused by grain packing and clay cementation within the sand fraction. Adding organic matter would decrease the strength or eliminate the crust (Parady, 1980). The company plans to add organic matter (in the form of stockyard manure or a green manure crop) if research determines it is necessary. Straw mulch would also be applied on dump slopes at a rate of 2 tons/acre, and would be crimped into the soil and alluvial material along the contour. A wood fiber cellulose or comparable hydromulch would be used on the flat dump tops where erosion is not expected to be a significant problem. All of the above treatments would serve to increase water retention capacity by protecting the surface from direct sunlight (decreasing evaporation) and providing a source of badly-needed organic matter.

Using stockyard manure on all dump surfaces may not be feasible: to raise the average organic matter percentage in the surface 6 inches to just 1 percent, approximately 4,800 cubic yards (3 acre-feet) of manure would be necessary. Even assuming that this quantity of manure would be available, such a treatment would be short term--after only 1 year, the organic matter would be somewhat less than 1 percent due to erosion and the rapid breakdown of the manure. In addition, it would be many years before the vegetation cover significantly increased organic matter in the soils and alluvium. This indicates that at least 2 or 3 times the volume of manure mentioned above would have to be added to significantly increase and maintain water retention capacity over the initial reclamation years. Such a treatment may only be practical on the dry south- and west-facing slopes where any increase in moisture retention would be significant. This would cut down the amount of stockyard manure to less than half of the amount necessary for all dump surfaces.

Finally, unsterilized stockyard manure would be a source of seed for unwanted weedy species which could grow rapidly and compete with the desired vegetation, adversely affecting growth and establishment.

The company has orally stated that it is considering the feasibility of planting a green manure crop (such as clover) in the alluvium. At the end of the first growing season, the crop would be plowed in while green to increase organic matter in the alluvium. However, at least 2-3 crops over 2-3 years would be needed to significantly increase organic matter, based on studies near Colstrip (Ed DePuit, University of Wyoming, oral commun., March 5, 1981). Furthermore, the green manure crops are of doubtful value in dry areas (such as Butte) because they may use up moisture (through growth or decay) that would otherwise be available for permanent vegetation (Buckman and Brady, 1969, p. 577).

The company proposes to apply 2 tons/acre of straw mulch to dump slopes. This would help control erosion and would increase water retention and nutrient adsorption capacity for the short term by providing a source of organic matter. The straw would also increase available moisture by reflecting sunlight. This would decrease the amount of heat reaching the surface of the alluvium, and decrease evaporation.

The company also proposes to apply a wood fiber or comparable hydromulch to the dump tops to protect the surface and increase organic matter.

6. Soil Salvage

Anaconda would reserve salvaged soil material for final dump top surfaces or critical areas such as south-facing slopes (see table II-1). Using salvaged soil material on the alluvium-veneered dump surfaces would increase organic matter on the surface, which would decrease erosion potential (see Erosion) and increase water retention and nutrient adsorption capacity. To accomplish this, the soil would have to be salvaged in 2 lifts. The first lift would take only the surface horizon and the second lift would take the remaining soil material considered adequate for reclamation. The 2 lifts would then be stored separately. This would ensure that the desirable surface material would be redistributed on the surface where it would be most beneficial.

However, Anaconda is proposing a 1-lift salvage operation. Because most of the soils have a thin surface horizon, this would dilute the desirable surface horizon with less desirable subsurface material. The resulting material may have little value over the alluvium because the texture of the alluvium and the soil material is very similar. An exception would be the Oro Fino soils from the Columbia Gardens area. These soils, with their thick, organic-rich surface horizons and increased clay in their subsoils, may still be desirable over the alluvium after mixing.

Because there is only about 35 acre-feet of Columbia Gardens soils, its use should be restricted to the critical south and west aspects of both dumps, which comprise about 92 acres. The average depth of this material over the 92 acres would be about 4.6 inches, and, after dilution with subsoil material and alluvium, would probably contain about 1-2 percent organic matter.

The relatively flat dump tops would not have the potential surface runoff of water as would the slopes, and the north and east-facing slopes would not have the moisture loss caused by lengthy exposure to the sun, as would the south and west-facing slopes. In addition, over the long term, the north and east aspects would probably have a greater increase in organic matter from a denser stand of vegetation than would the south and west aspects,and therefore, the organic matter remaining after erosion losses would tend to be greater on the north and east aspects. Therefore, any increases in organic matter and clay content on the south and west aspects (such as from addition of Columbia Gardens soils), would aid short-term vegetation establishment. However, erosion would remove the topsoil (with its 2 percent organic matter) within 100 years (see Geomorphology). The remaining alluvial layer would contain less than 1 percent organic matter; the only major source would be decaying roots--surface litter would be removed by erosion (Bernie Jensen, Montana State University, oral commun., February 26, 1981). The decrease in organic matter on the critical south- and west-facing slopes would reduce moisture and nutrient-holding capacity, adversely affecting vegetation (see Vegetation).

C. Vegetation

1. Summary

Construction of the waste dumps would destroy most of the existing vegetation in the proposed permit area. Revegetation of the dump surfaces would begin after the first lift is complete (within the first year of mining). Revegetation would continue as each additional lift is completed. After reclamation, plant species diversity would probably not be as extensive as before dumping due to the erosion problems which are expected to increase with time (discussed below), droughtiness, surface crusting, metal toxicity, and low nutrients.

Because the company would maintain and intensively manage the dump surfaces for the short term (roughly the first 20 years), initial vegetation success is expected to be fair to good. For the middle term (approximately 20-100 years), vegetative cover would begin to deteriorate due to the greatly increased erosion on the long, unmaintained slopes. Long term (100+ years) impacts on vegetation would be severe, because gullies on the unmaintained slopes would continue to grow until the waste rock core is exposed and potentially toxic material is released.

2. General Reclamation Problems

The droughty nature of the soils and alluvium (see Soils and Alluvium) would decrease vegetation density and species diversity on all dump surfaces. Vegetation growing on the south and west aspects would be most severely affected, because those slopes are hot and dry from lengthy exposure to the sun.

The alluvial material has a tendency to form surficial crusts when dry. This could impede seedling emergence if the surface dried out immediately after germination (see Soils and Alluvium). The likelihood of this is not known.

Metal toxicity could cause localized vegetation failures in areas about 0.1 acre to a few acres in size (see Soils and Alluvium).

The low nutrient holding capacity of the soils and alluvium (see Soils and Alluvium) would not have much effect on the vegetation as long as the company fertilizes as needed. However, after management of the dumps is terminated, nutrients not used by the plants may be leached out of the rooting zone in a few growing seasons (see chapter IV, Technological Alternatives).

3. Short Term (up to 20 years from start of reclamation)

The company would intensively manage and maintain the dumps for approximately 20 years from the start of reclamation. This commitment includes erosion control measures (see chapter I) as well as replanting if vegetation should fail. Because of these measures, vegetation success is expected to be fair to good for the short term.

4. Middle Term (from approximately 20 to 100 years)

After approximately 20 years, or when the vegetation appears to be well established, the company would end its management and maintenance of the dump surfaces. In the years following, vegetative cover is expected to deteriorate as a result of increasing gully erosion in the soil and alluvial material on the dump slopes (see Geomorphology). Some vegetation would grow between the gullies that dissected the slopes. Sheet and rill erosion would cause pedestaling of existing vegetation. This could eventually expose the roots and possibly kill the affected plants. In addition, erosion would wash away some of the new seed from the existing vegetation. The increased erosion (see Geomorphology) would decrease plant root density and increase runoff (Lusby and Toy, 1976). Less water would infiltrate into the rooting zone, which would add to the droughtiness problem discussed above and in Soils and Alluvium. Because soil would be eroded faster than it formed, it would not develop pronounced horizons or structure. This would limit vegetation development compared to natural soils.

Vegetation growing at the base of the dump slopes would probably be gradually covered by sediment eroded off of the slopes above. Because of the continual deposition of sediment, new vegetation attempting to grow on previously deposited sediment may be covered by more sediment.

In addition to the physical effects of the sediment, some evidence of chemical toxicity was noticed at the base of the south dump. This may have been caused by contaminated runoff water from the deep gullies where waste rock is exposed on the dump face.

Vegetation monitoring on the dump slopes would probably continue after the berms and terraces are filled and until the company pettions for bond release. Information gathered from the proposed monitoring program would give the company (and DSL) an indication as to the need for any changes in their reclamation techniques.

5. Long Term (100+ years)

Long term effects on vegetation are highly speculative; a best guess is that for the first few centuries the slope faces would appear as areas of green vegetation dissected by unvegetated gullies. The gullies would become larger with time. Sheet and rill erosion and the lack of appreciable moisture and nutrients would cause a decrease in species diversity and density on the areas between the gullies. This problem would grow worse as available organic matter is carried downslope by erosion.

The exposure of the waste rock in hundreds of years (see Geomorphology) may create problems for any remaining vegetation. Water contaminated by the waste rock (see Hydrology) would probably kill some vegetation on the slopes and near the base of the slopes.

After thousands of years, the waste rock core of the dumps would be exposed (see Geomorphology). No vegetation would grow where the waste rock contained high concentrations of toxic elements; where the waste rock was not toxic, some pioneer species would grow. The waste rock has not been sufficiently sampled to determine the extent of such toxic areas.

6. Plant Species Composition

Plant species proposed for revegetation of the dumps are listed in table III-3. The company proposes an average seeding rate of about 80 pure live seeds per square foot. The majority of the species listed, particularly the grasses, are suitable for anticipated conditions at the dump sites.

The majority of the reclaimed canopy cover would consist of wheatgrasses (*Agropyron* spp.), fescues (*Festuca* spp.), and bluegrass (*Poa* spp.). Based on discussions with personnel from the Montana Agricultural Experiment Station and the recent study in southeastern Montana by DePuit and others (1980), wheatgrasses would be expected to dominate the canopy cover. The thickspike/streambank wheatgrass (*Agropyron dasystachyum*/*Agropyron riparium*) complex is expected to develop quickly. Lesser amounts of western wheatgrass (*Agropyron smithii*) and slender wheatgrass (*Agropyron trachycaulum*) would be present. Hard fescue (*Festuca ovina var. duriscula*), sheep fescue (*Festuca ovina*), and Canada bluegrass (*Poa compressa*) are also expected to do fairly well.

TABLE III-3.--Plant species proposed for revegetation of dumps

[Source: Anaconda's permit application]

Common Name	Scientific Name
Idaho fescue	*Festuca idahoensis*
sheep fescue	*Festuca ovina*
hard fescue	*Festuca ovina var. duriscula*
streambank wheatgrass	*Agropyron riparium*
western wheatgrass	*Agropyron smithii*
thickspike wheatgrass	*Agropyron dasystachyum*
slender wheatgrass	*Agropyron trachycaulum*
green needlegrass	*Stipa viridula*
Canada bluegrass	*Poa compressa*
prairie sandreed	*Calamovilfa longifolia*
alfalfa (Ladak 75 variety)	*Medicago sativa*
lupine (native)	*Lupinus spp.*
cicer milkvetch	*Astragalus cicer*
common chokecherry	*Prunus virginiana*
green rabbitbrush	*Chrysothamnus viscidiflorus*
antelope bitterbrush	*Purshia tridentata*
fourwing saltbush	*Atriplex canescens*
wild rose	*Rosa spp.*
sticky currant	*Ribes viscosissimum*
Rocky Mountain juniper	*Juniperus scopulorum*
common juniper	*Juniperus communis*
creeping juniper	*Juniperus horizontalis*
lodgepole pine	*Pinus contorta*
Douglas-fir	*Pseudotsuga menziesii*
quaking aspen	*Populus tremuloides*
thinleaf alder	*Alnus tenuifolia*

The company proposes to include seed for a quick-growing annual stabilizer or "nurse" crop with the perennial seed mixture. An annual stabilizer crop such as Horsford barley would germinate and grow rapidly. Because of its dense foliage and laterally-spreading fibrous root system, the barley would stabilize the highly erodible sandy alluvium. In addition, the annual crop would assist perennial plants by reducing sandblasting of seedlings, minimizing surface temperature extremes, and holding snow cover which would increase moisture reserves (Jensen and Hodder, 1979).

The steep 24° slopes proposed by the company for some of the dump slopes (see chapter I) would limit access by reclamation machinery. Farmer and Blue (1978) found that: 1) slopes steeper than 22° cannot be safely worked on the contour because of rollover hazard; 2) erosion on the steep slopes would move seed and fertilizer downslope, causing poor seed distribution and bare spots; and 3) seeder-packers (such as the Brillion® seeder the company proposes to use) or seed drills do not work properly on very steep slopes when operated along the contour (poor seed planting). The above researchers concluded that waste dumps should be constructed so that faces are not steeper than 22°.

Revegetation success would be enhanced by using different species mixtures on north and east slopes, south and west slopes, and dump tops. Seed mixtures for each zone could be composed of species appropriate for conditions at each site. The south and west aspects would have the harshest environmental conditions: high erosion rates, droughtiness, and heat. North and east aspects would be most favorable for plant growth: More moisture would be available for the plants, although erosion would still occur to some extent because of the steep, long slopes. The relatively flat dump tops would not erode severely; however, this area would be subject to drying by exposure to sun and wind.

Some species may not be appropriate for the Butte area because of the low average annual precipitation (about 11.5 inches). Idaho fescue (Festuca idahoensis), for example, usually requires about 15 inches of rainfall for adequate growth. This requirement would essentially eliminate this species from all dump zones, with the possible exception of the north and east aspects where microsites could provide this moisture requirement.

Several of the plants listed in table III-3 may not be appropriate on certain aspects for various reasons, as discussed below.

Prairie sandreed (Calamovilfa longifolia) is a warm-season grass, meaning that annual growth is delayed until later in the growing season. The other grasses in the mixture are cool-season grasses that germinate and begin growth early in the season before the prairie sandreed. Therefore, the prairie sandreed would have to compete against the partially established cool-season grasses. The net moisture deficit that occurs in the Butte area during the latter part of the growing season would also limit the success of this species.

The alfalfa variety (Medicago sativa, Ladak 75) has been used in other problem areas with good results (DePuit and Dollhopf, 1978). However, alfalfa would aggressively compete with native species. DePuit and others (1980) found that elimination of aggressive introduced species (such as alfalfa) from seeding mixtures helped establish native species on mined lands in southeastern Montana. Therefore, it may be desirable to reserve alfalfa for use as a hedge against failure in problem areas.

Tree and shrub species requiring relatively moist sites, such as Douglas-fir (Pseudotsuga menziesii), aspen (Populus tremuloides), alder (Alnus tenuifolia), chokecherry (Prunus virginiana), currant (Ribes viscosissimum), and wild rose (Rosa spp.) would probably not succeed on south and west slopes and may have limited success on the dump tops. Success of those species on the north and east slopes would depend on moisture available in microsites. Irrigation of Douglas-fir seedlings for 1 year would greatly improve success (Nellie Stark, University of Montana, oral commun., February 18, 1981). Lodgepole pine (Pinus contorta) is unpredictable; success of this species is more likely than for Douglas-fir.

Three of the shrub species listed in table III-3--antelope bitterbush (Purshia tridentata), fourwing saltbush (Atriplex canescens), and green rabbitbrush (Chrysothamnus viscidiflorus)--are expected to do relatively well. These could be included in the species mixture for dump tops and south and west aspects as well as for the north and east aspects.

Of all the trees and shrubs listed in the table, the junipers are most likely to survive. These species (Juniperus scopulorum, Juniperus communis, and Juniperus horizontalis) would exhibit fair to good survival rates because they are generally tolerant of relatively dry sites. They could be included in the species mixture for the north and east aspects and the dump tops. Some might survive on the dry south and west aspects.

A few additional species not proposed by the company might perform well on the dumps and could be added to the species mixture. These include Indian ricegrass (Oryzopsis hymenoides), skunkbush sumac (Rhus trilobata), mountain mahogany (Cerocarpus montanus), and to a lesser extent, snowberry (Symphoricarpos spp.)

Indian ricegrass generally performs well on sandy soil during the first two years of growth, but tends to gradually disappear (DePuit and others, 1980). This species would help control erosion during initial reclamation. Skunkbush sumac, mountain mahogany and snowberry do not do well in dry conditions and would be best suited to the north and east slopes and possibly the dump tops.

D. WILDLIFE

Impacts on wildlife would generally be limited to small mammals and non-game birds inhabiting the permit area (see chapter II, Wildlife). Because the species affected are relatively common and widespread, and because similar unimpacted habitats exist immediately adjacent to the permit area, the chance of local extinction or substantial reduction in population size is slight. Human uses of wildlife would not be significantly affected, because little direct use is made of the permit area's wildlife.

Waste rock dumping would temporarily reduce wildlife habitat within the proposed permit area. Habitat loss would be greatest for species with small home ranges and territories, particularly small mammals and birds. Less mobile individuals would be destroyed as dumping covered their habitat: for example, each acre of rubber rabbit/brush/grassland habitat lost would result in the loss of an estimated 13 deer mouse, 15 voles and 1 chipmunk (Rudio, 1980). Mobile individuals (birds) would survive only if they found unoccupied, suitable habitat elsewhere. Depending on the season that disturbance occurs, breeding territories may be altered or destroyed.

Permanent habitat loss would occur as a result of the southeasterly expansion of the Berkeley Pit. Under the current mining plan, the expansion would cover 19 acres. This area would be essentially unused by wildlife.

Species diversity would be reduced with the expected loss of vegetation diversity. Sparse grassland or grassland/shrub types can be expected to regenerate over much of the area (see Vegetation). The dump tops and south and west slopes probably would have few trees; therefore, grassland species such as horned lark, lark sparrow, meadowlark and deer mouse would be expected to occupy the area. The shift from tree types (aspen, willow, lodgepole) to open types would reduce diversity by excluding primary and secondary cavity nesters as well as other woodland species.

Noise and human presence would disturb some sensitive species, excluding them from suitable habitat. For example, Berry (1980, p. 454-455) found substantial effects from off-road vehicles on four bird species found within the 158 permit boundary: mourning dove, common flicker, cedar waxwing, and western meadowlark. Effects ranged from displacement of up to 3.2 km to early flushing and use of thorny brush for protection.

The intermittent streams in the proposed permit area would essentially be eliminated; however, only pollution-tolerant invertebrates are likely to inhabit those streams at present. Long-term ground water contamination from the Berkeley Pit (see Hydrology) could seriously affect fisheries in Silver Bow Creek; however, that fishery is currently limited. If plants accumulated toxic levels of metals (see Soils and Alluvium), the overall health and reproductive success of animals utilizing those plants could be reduced.

E. HYDROLOGY

1. Summary of Impacts

Short-term hydrologic impacts from the waste dumps would be minimal, because the company would maintain its proposed surface runoff diversion system, and because any contaminated ground water would probably be captured. Long-term hydrologic impacts (hundreds of years from now) could be severe, because the proposed runoff diversion systems could eventually fail if not properly maintained. The Berkeley Pit would intercept runoff from the north dump, but streams cutting into the south dump may eventually deposit sediment and focus contaminated runoff into what is now a residential area south of the dump. The runoff diversion around the south dump would require long term periodic cleaning in order to prevent contamination of offsite waterways.

2. Surface Water

a. Short term effects

Impacts on offsite water quality would be minimal as long as Anaconda maintained its proposed contaminated water treatment system. Some sediment eroded from the south dump would remain in suspension, but any runoff water that does not meet the standards for total suspended solids set by the Montana Water Quality Bureau would be directed to a waste water treatment system.

Until 1987, runoff from the south- and west-facing slopes of the south dump--the most erosive slopes--would be directed to a sediment pond northwest of the dump. After 1987, runoff from these slopes would be sent to the Berkeley complex waste water treatment system before it is released to Silver Bow Creek.

b. Long term effects

Anaconda's proposed water diversion system would be capable of carrying the volume of runoff expected on the average once every 100 years (see chapter I, Mining Plan). There is about a 65 percent chance that the design capacity of the proposed diversion ditches and pipes would be exceeded within the next 100 years (Dunne and Leopold, 1979, p. 55). Over a longer time the chances are greater that the design capacity of the system would be exceeded. If the diversion systems were not periodically maintained, the diverted streams would be forced by the topography into the base of the dump. The streams would continue to erode the upstream side of the dump until new channels were formed that more closely follow the natural slope of the land. This would probably occur within hundreds of years if corrective actions were not taken and would continue for thousands of years until a considerable portion of the dump had been removed. The alluvial veneer of the dumps could easily become saturated, causing localized slumps or failures. Slumps could also be caused by undercutting from the streams. In addition, gullies would erode the alluvium during this period, exposing the waste rock core of the dump (see Geomorphology). Repairing all ditch failures and unplugging all clogged pipes would prevent this problem.

The waste rock contains pyrite and metals that could contaminate considerable amounts of runoff and stream water. Pyrite in the waste rock would acidify water which came in contact with it. The acidified water would in turn solubilize metals contained in the waste rock.

Waste rock that is freshly exposed may produce very poor quality water. The waste rock would eventually form a coating of iron hydroxide, which would help reduce the erosion of the waste dump material and reduce (but not eliminate) the amount of contaminants in the water that came in contact with the waste rock (John Sonderegger, oral commun., March 16, 1981). Based upon samples taken from water exposed to waste rock at Butte, runoff water exposed to the waste rock would be unsuitable for drinking water (Hydrometrics, 1980, p. 12), but not as bad as the poor quality ground water in the area (see Groundwater).

Most of the sediment eroded from the south dump would be deposited at the toe of the dump. After 100's or 1000's of years, eroded sediment could fill the diversion ditch designed to carry dump runoff water to the Berkeley Pit, and send the runoff south into Blacktail Creek. Failure of the diversion system could interfere with land uses in what is now a residential area. If contaminated runoff water from the dumps were to reach Blacktail or Silver Bow Creeks, the aquatic life in them could be severely impacted (see Wildlife).

Elk Park Canyon would be filled with over 200 feet of waste rock and alluvium to form the north dump. Although the intake to the pipe underneath the dump would be screened, debris could eventually plug it, particularly after mine abandonment. If the intake were plugged, the dump would act as a dam across Elk Park Canyon. Although the wasterock and alluvium is fairly permeable, the upstream side of the dump could eventually seal as fine material worked into the pore spaces. This would form a dam that could saturate part of the dump, causing slumps or shearing failures. If this were to happen and the dump were overtopped or breached, large amounts of the dump could be carried downgradient. The Berkeley Pit would be extended eastward under Anaconda's proposal such that sediment and contaminated water from the north dump would flow into the pit. Since the Berkeley Pit would act as a buffer between the north dump and Silver Bow Valley, failure of the pipe system under the north dump would not be as critical a hydrologic problem as the failure of the diversion system around the south dump.

The pipe under the north dump could not be expected to work permanently without periodic maintenance. Dumping the waste rock elsewhere would prevent the problem but would also increase operating expenses for the Anaconda Copper Company (see chapter IV, Modification of the Proposed Permit).

c. Long term use of the Berkeley Pit

Once mining ceased, contaminated surface waters from mining disturbances would be directed into the Berkeley Pit. The Berkeley Pit would fill with water, because the company would no longer pump ground water out of the pit and underground workings. Within 10 years, the pit could fill to the point where water would flow out into the alluvial ground water system of the Silver Bow Basin. For several years or perhaps a few decades, the quality of water in the pit would be poor (total dissolved solids probably in excess of 2,000 mg/l). Seepage of this poor quality water into the ground water system could eventually reach Silver Bow Creek; ground water surfaced just south of the present pit before underground pumping started in the late 1800's - early 1900's (see chapter II, Hydrology).

The quality of water in the Berkeley Pit would eventually improve. Once the pit filled, less pyrite would be oxidized, which would decrease the acidity of the pit water. This would also decrease the amount of metals in the pit water (John Sonderegger, oral commun., March 16, 1981). It is expected that total dissolved solids in the pit water would decrease to 800 to 1,200 mg/l (table III-4). The alluvium and bedrock through which the pit water would travel before reaching Silver Bow Creek would adsorb additional metals (Diebold, 1974, p. 19), reducing the potential for pollution of Silver Bow Creek.

If substantial amounts of surface water from areas not disturbed by mining were directed into the pit (i.e., Silver Bow Creek and Yankee Doodle Creek), then the quality of water in the pit would probably improve (see chapter IV, Technological Alternatives).

d. Tailings pond

The concentrator tailings pond in the Yankee Doodle Creek and Silver Bow Creek drainages would be raised 165 feet under the current proposal. The pond would be raised an additional 30 feet if the company proceeded with underground block caving (Ed Bartlett, written commun., October 7, 1980).

Anaconda has hired a consultant to study the stability of the tailings dam in compliance with an order of the Army Corp of Engineers to inspect all earthfill dams. Results of the study are not available, but it appears that the mass of the material used to construct the tailing dam would preclude it failing by slumping.

Silver Bow Creek and Yankee Doodle Creek, which flow into the tailings pond, could overtop and erode the dam after the mine is abandoned. It is not known what provisions the company might take to prevent this. Material eroded from the tailings pond would enter the Berkeley Pit and would lower the quality of water in the pit and possibly off-site ground water or surface water.

e. Warm Springs settling ponds

Silver Bow Creek is diverted into the Warm Springs settling ponds near Anaconda before it reaches the Clark Fork River. The ponds are fairly effective in reducing metals in the surface waters of Silver Bow Creek, but they are not totally effective in removing sulfates (Botz and Karp, 1979, p. 11); however, the proposed waste dump expansion would not measurably affect sulfate concentrations in Silver Bow Creek.

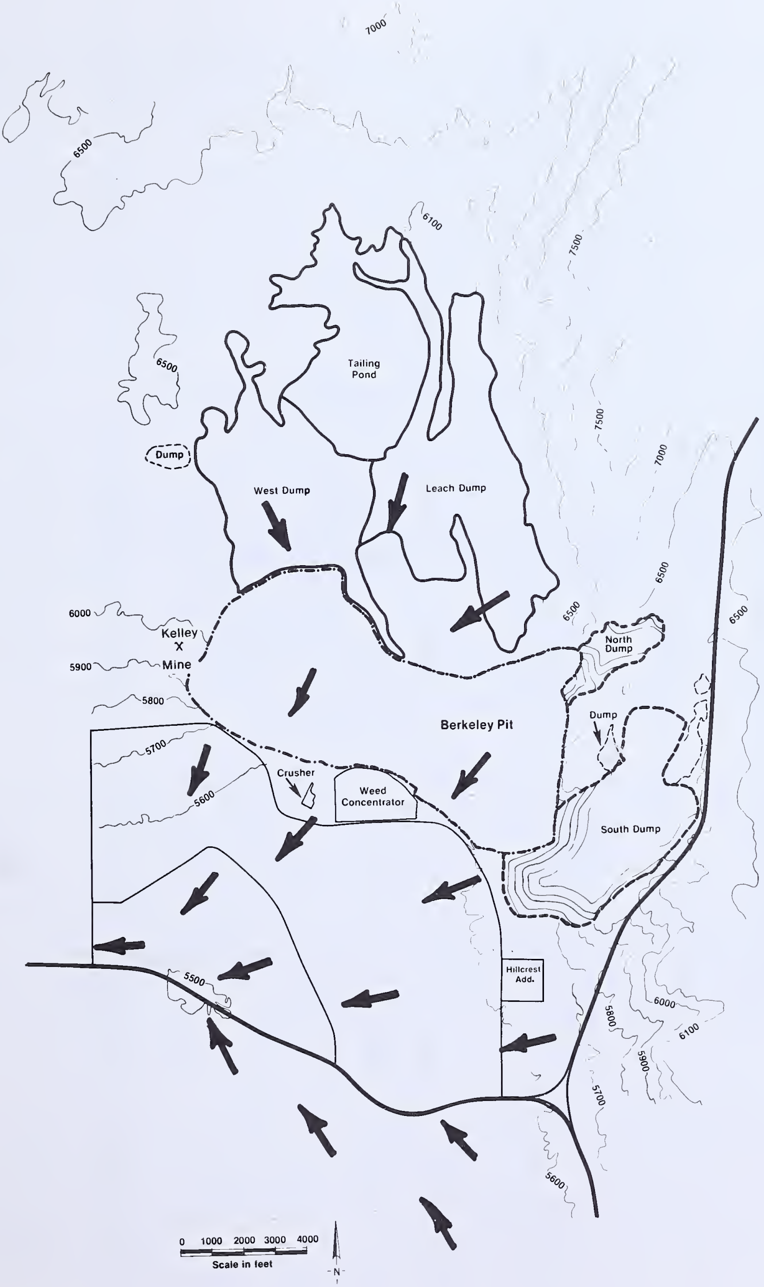


FIGURE III-2.--Generalized post-mining ground water flow direction.

TABLE III-4.--Ground water quality of the Silver Bow Valley compared to expected quality of water in the Berkeley Pit

[Data are in mg/L. Leaders (---) indicate no data.]

		SILVER BOW VALLEY ALLUVIUM		BERKELEY PIT		
				Initial pit water[4]	10-20 years after dumping stops	
Parameter	Suggested drinking water limits[1]	Coca Cola Co. Well south of pit T3NR7W20ACA[2]	Well due west of South Dump T3NR7W20ADAA[3]		Uncontaminated surface water not added to pit[5]	Uncontaminated surface water added to pit[5]
Acidity (pH)	---	6.8	6.8	2.0-2.5	<6.5	6.0-7.0
Total dissolved solids (TDS)	500	295	360	9000	800-1200	500
Sulfate (SO_4)	250	161	200	5000	450-850	275-350
Iron (Fe)	0.3	---	6.24	700	15-85	10-35
Aluminum (Al)	---	---	<0.05	180	0.1-0.6	<.3
Copper (Ca)	1.0	---	1.20	190	2-4	<2
Zinc (Zn)	5.0	---	0.22	170	0.5-18	<8
Magnesium (Mg)	0.05	13	12.80	170	20-43	<20

[1] U.S Public Health Service (1962).

[2] Botz (1969).

[3] Anaconda Copper Company data files.

[4] Spindler (1977, p. 2).

[5] TDS and pH, John Sonderegger, Montana Bureau of Mines and Geology, written commun., November 3, 1980; remaining values estimated based upon ratio of TDS to specific values of shallow ground water wells near the pit.

The Warm Springs settling ponds pose a hazard, because they were constructed on the flood plain of Silver Bow Creek. A very large flood could sweep away part of the ponds, severely affecting aquatic life in the Clark Fork River. This is not likely to occur while Anaconda is operating at Butte, because the company controls the flow of Silver Bow Creek above its confluence with Blacktail Creek and has eliminated extremely high peak flows in Silver Bow Creek. After mine abandonment, surface waters above the Butte operations (Yankee Doodle and Silver Bow Creek) could be directed into the Berkeley Pit. If they were diverted into the pit, then peak flows in the Silver Bow Creek and therefore flood hazard posed by the Warm Springs ponds would be lower.

3. Ground Water

a. Effect of waste dumps on ground water quality

The proposed waste dumps would not appreciably affect ground water quality in the Silver Bow Valley during and immediately following construction. As long as the Anaconda Copper Company continue to pump their underground workings (estimated to be about the year 2000), ground water would continue to flow towards the pit. Any contaminated ground water generated by the waste dumps would be intercepted and recycled in the wastewater treatment system, minimizing offsite ground water contamination.

Ground water contaminated by the north dump would be intercepted by the Berkeley Pit even after the Berkeley Pit filled with water. The north dump would, at most, add slightly to the overall contamination of the Silver Bow Valley ground water, because the pit would act as a buffer between the north dump and the Valley.

Most of the ground water contaminated by the south dump would not be intercepted by the pit after underground pumping stopped and the Berkeley Pit filled with water. Water coming in contact with waste rock in the south dump would directly enter the ground water system of the Silver Bow Valley. This direct contamination could slightly increase the metal concentrations of the Silver Bow Valley ground water system. Ground water wells downgradient of the south dump could be pumped periodically, effectively stopping most of the contaminated dump water from reaching Silver Bow Creek. The pumped water would have to be treated. After the company stopped pumping and treating the contaminated ground water, it would enter the Silver Bow ground water system possibly degrading its water quality.

After thousands of years, the waste rock core of the dump would be exposed as the alluvial veneer is removed by erosion (see Geomorphology). The waste rock would then be more readily exposed to oxygen and water, increasing the contamination of ground water slightly. There are two reasons why the waste rock would not present as serious a ground water quality problem as would be thought considering the amount of pyrite and heavy metals in the waste rock. First, the waste rock would probably become fairly compact over time, which would tend to limit deep perculation of surface water through the dump. Second, the surface of the waste rock would also tend to form an iron hydroxide crust, thereby limiting the erosion of the waste rock and the formation of contaminated surface and ground water (see Surface Water). If pumping from the wells downgradient of the dump stopped, exposure of the entire waste rock core would degrade nearby ground water to a limited extent. The amount of metals and dissolved constitutents created by the waste rock would be hard to estimate, but may be enough to noticably effect the ground water immediately downgradient of the dump (see fig. III-2).

The cumulative impact of mining activities on the ground waters and surface waters of the Silver Bow Valley could be significant. The significance of contaminated water from the waste dumps would depend primarily upon the human use of these waters at that time and the amount of contaminated water generated by other sources. Other sources include natural contributors of degraded ground waters (oxidized bedrock) and contributions added by other parts of Anaconda's Butte operations, primarily the Berkeley Pit. The waste rock dumps would add to the cumulative amounts of pollutants released to the ground water of the Silver Bow Valley, if nothing were done to prevent it. Pumping wells downgradient of the dumps periodically would prevent contaminated ground water created by the south dump from reaching the valley (see Technological Alternatives).

b. Effect of Berkeley pit on ground water quality

Ground water quality in the Silver Bow Valley could be degraded by Anaconda's proposal to direct all contaminated surface and ground water from the Butte operation into the Berkeley Pit when mining ends. This impact would probably be more severe than the effect of the waste dumps on ground water. After mine abandonment, Anaconda would no longer pump water from the Berkeley Pit and the underground workings. The pit would fill with water, probably within a decade, and ground water would flow into the Silver Bow Valley as it did before mining began at Butte (fig. III-2).

The amount of metals and other dissolved constituents that would reach the ground water of the Silver Bow Valley depends on the rate of ground water flow from the pit and the acidity of the pit water. The amount of ground water seeping out of the Berkeley Pit once it is filled would probably be substantial; in the order of millions of gallons per day. The actual rate of ground water flow from the pit would be difficult to estimate and would depend on the amount of surface runoff directed into the pit, the rate of ground water inflow, and the amount of evaporation from the pit lake.

As the pit begins to fill, the quality of pit water would be poor; very acidic (pH of 2) and highly mineralized. The water would become less acidic and mineralized as oxygen was depleted. An equilibrium would be approached 10-25 years after pumping ceased (John Sonderegger, Montana Bureau of Mines and Geology, written commun., November 3, 1980). Table III-4 compares ground water quality in the Silver Bow Valley with the expected quality of water in the Berkeley Pit once it is filled. If substantial amounts of poor quality water seeped out of the pit, concentrations of metals in ground water west of Butte would increase and could even affect the quality of water in the Silver Bow Creek (see Surface Water). The proposed waste dumps would probably contribute only very slightly to those concentrations, but the cumulative impacts could be significant.

Standards for ground water quality will probably be adopted by the Montana Board of Health in 1982. The only current standards by which to assess ground water impacts are the recommended limits for drinking water (table III-4). If substantial quantities of poor quality water seeped out of the pit into the nearby ground water, then ground water downgradient could become unsafe for use as drinking water. Only a few domestic wells that tap the ground water of the Silver Bow Valley between the Berkeley Pit and the community of Rocker (Don McLean, Butte-Silver Bow County Sanitarian, oral commun., February, 1981). However, because the ground water feeds into Silver Bow Creek, potential degradation of Silver Bow Creek may be an important consideration. The combination of seepage from the Berkeley Pit and other sources of contaminants could significantly add to the water quality problem of Silver Bow Creek. Studies will have to be undertaken to determine the magnitude of poor quality water seepage from the Berkeley Pit. A few possible mitigation measures are discussed in chapter IV (Technological Alternatives).

c. Quantity and flow direction changes

After the Berkeley Pit has filled with surface and ground water (about 2005), several million gallons per day may seep through the ground water system out of the Berkeley Pit and into the Silver Bow Valley. Marshy areas along Blacktail Creek and Silver Bow Creek, which existed before mining began, would probably reappear. Basements of numerous homes and businesses in the lower part of the valley south of the Berkeley Pit could be flooded as a result of the raised water table. Several homes and businesses might have to be abandoned. Little could be done to prevent the elevated water table in this area since the area has been dry only as a result of underground pumping at the mines. The artifically lowered water table has probably existed since the turn of the century. As long as the company continued to pump from the areas north of the potential marsh, the water table would not rise.

4. Geologic Hazards

The filling of the Berkeley Pit with water could trigger earthquakes and cause underground tunnels under Butte to collapse (see Geology).

5. Warm Spring and Opportunity Ponds

The Warm Springs ponds would still be used by Anaconda for additional treatment of Silver Bow Creek. Therefore, degradation of ground water immediately under and downgradient of the ponds would still occur. No ground water wells used for agricultural or domestic purposes appear to be effected by seepage from the ponds.

The ponds remove more pollutants than they produce and are essential in maintaining the relatively good aquatic environment of the Clark Fork River. The amounts of sulfide in the river immediately downstream of the ponds now exceed the standards set by the Department of Health and Environmental Science. This is primarily caused by seepage out of the ponds and into the ground water which eventually seeps into the Clark Fork River. Despite this problem the ponds should continue to function as effective removers of pollutants from the surface waters of Silver Bow Creek.

F. GEOLOGY

1. Earthquakes

Construction of the north and south dumps probably should not induce earthquakes on the Continental Fault. The Continental Fault lies along a north-south line between the Berkeley Pit and the dump sites. The transfer of weight from the side of the fault that appears to be downthrown (west) to the side that appears to be upthrown (east) may have a stabilizing effect on the fault.

During active mining, vibrations caused by blasting and removal of large amounts of material from the Berkeley Pit expansion could cause the Continental or some other fault in the area to slip prematurely. The resultant earthquake could cause considerable damage to Butte; however, the possibility of this occurring within the next 20 years of mining is remote (see chapter II, Geology). Under the worse set of circumstances active mining at Butte would cause an earthquake(s) to occur sooner than it might otherwise. The severity of such a quake(s) would probably be equal to or less than that which would have occurred if mining were not going on at Butte.

Dewatering of the bedrock to allow open pit and underground mining has undoubtedly increased the stability of faults in the area. After the mine is abandoned and the Berkeley Pit filled with waste water (see chapter III, Hydrology), faults which have been dry for numerous decades would again become saturated by ground water. Since water acts as a lubricant between fault blocks, faults in the Butte area may have been artifically locked in place. Upon resaturation nearby faults could slip due to built-up pressures and cause an earthquake(s).

Filling of the Berkeley Pit with water would add a rather large amount of weight to the downthrown side of the Continental Fault within a relatively short time. The additional weight of water and the resaturation of near surface fault could increase the number and size of earthquakes occurring at Butte. The annual filling of Lake Mead behind Boulder

Dam in California was strongly correlated with increase earthquake activity (Charles Wideman, Testimony in Kadillak, et. al., v. Anaconda, et. al., 1977).

Although the filling of the Berkeley Pit with water and the resaturation of the near surface faults could reactivate faults, the chances of a damaging earthquake occurring as a result is rather remote. The Butte area has recorded several earthquakes in modern times; the largest was a magnitude 3.9 quake in 1968 (Charles Wideman, testimony given in Kadillak, et. al. v. Anaconda Company, et. al., 1977). The maximum earthquake expected at Butte would be magnitude 7. This would cause great damage in Butte, especially to the older uptown district, and could cause loss of life. A magnitude 7 earthquake would probably occur only once every 1000 or more years at Butte (extrapolated from Quamar and Breuninger, 1979). Other parts of Montana are considered more vulnerable to earthquakes than Butte.

Presently, accurate earthquake predictions are impossible. About the only precautionary measure that could be done if Butte were to experience an increased occurrence of earthquakes would be for the citizens of Butte to abandon, raze or reinforce structurally unsound buildings.

2. Mineral Resource

Additional copper mineralization exists under the Berkeley Pit and under the old downtown district of Butte. Underground block caving could probably extend production at Butte past the year 2000. But, without surface mining operations, block caving would probably not be economically feasible at Butte (Al Dahlstrand, Anaconda Copper Company, oral commun.,). The amount and quality of mineralization is not known; therefore, no estimate beyond the year 2000 can be made. At the present time, this deep, mineralized ore zone is not considered economically recoverable, but such may not be the case in the future. The ever changing economics of copper and other metals makes estimates of future production at Butte very speculative.

3. Tunnel Collapse

When ground water levels return to near normal after the Berkeley Pit is filled with water, the old underground tunnels that honeycomb the Butte area may begin to collapse. There are over 2,600 miles of underground tunnels in the Butte area (Montana Water Quality Bureau, memo to Butte permit files, 1976). A few tunnels east of Main Street in Butte have reportedly already collapsed (Montana Bureau of Mines and Geology, oral commun., August 7, 1980). The timbers used for support are rotting and may lead to the collapse of the tunnels.

Once under ground pumping at Anaconda's Butte operations stops, underground tunnels would fill with water. The water would cause material on the ceilings and walls to spall off. As a result, additional collapses of near-surface tunnels could be expected. The consequences of such failures are not known, but buildings in the older district of uptown Butte may suffer damage as a result.

4. Waste Rock

High concentrations of zinc, arsenic, copper, cadmium, and lead in the waste rock could contaminate ground water (see Hydrology). In addition, plant toxicity problems could occur if waste rock material is exposed to plants at the surface or in the rooting zone. For the short term, plant toxicity problems due to waste rock exposure are not anticipated, because the company would veneer the waste dumps with at least 10-20 feet of alluvium. However, if deep erosion gullies occured, (see Geomorphology) the waste rock would be exposed which could cause toxicity problems locally and downslope. In the long-term (geologic time--thousand's of years), it is estimated that erosion would completely wash away the alluvium veneer, exposing the waste rock causing even greater water quality and vegetative problems.

G. CLIMATE

Continued mining at Butte would have no significant effect on the climate, because the pollutant sources are at or near ground level and would not change significantly. The amount of particulate reaching the upper atmosphere would be insufficient to cause any measurable climate modification.

H. AIR QUALITY

For the first 3 years of mining, there would be little change in the ambient air quality. The mining operation would be similar to that at present; emission rates of both particulates and gases would continue as described in chapter II, Air Quality. There would be some increase in TSP concentrations to the southeast of the permit area as mining proceeded in that direction (fig. III-3). Federal and Montana ambient air quality standards for TSP would continue to be exceeded in the nonattainment area.

Once the conveyor system began operation in 1984, there would be a significant improvement in ambient air quality (fig. III-4). The conveyor is expected to replace a substantial number of haul trucks, the major source of pollution from the Anaconda operation. By 1990, fugitive dust emissions would decline 50 percent to 6,500 tons/year, due to the decrease in haul truck traffic, and would remain at about 7,500 tons/year for the remainder of mine life (fig. III-5). There would also be significant reductions in the emissions of particulate and gases from diesel fuel combustion as the consumption of diesel fuel decreased (table III-5).

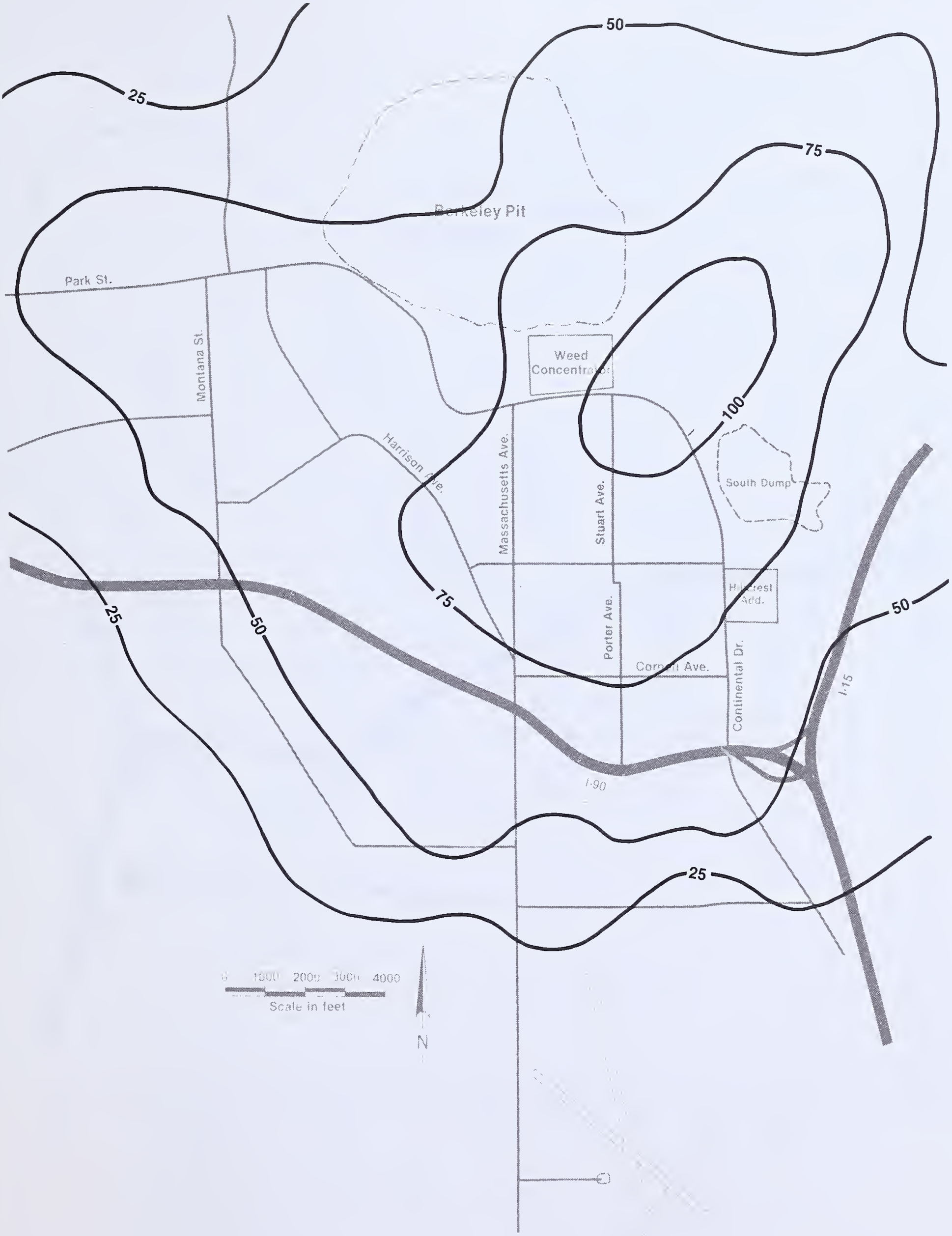


FIGURE III-3.--Predicted summer 1983 total suspended particulate (TSP) levels.

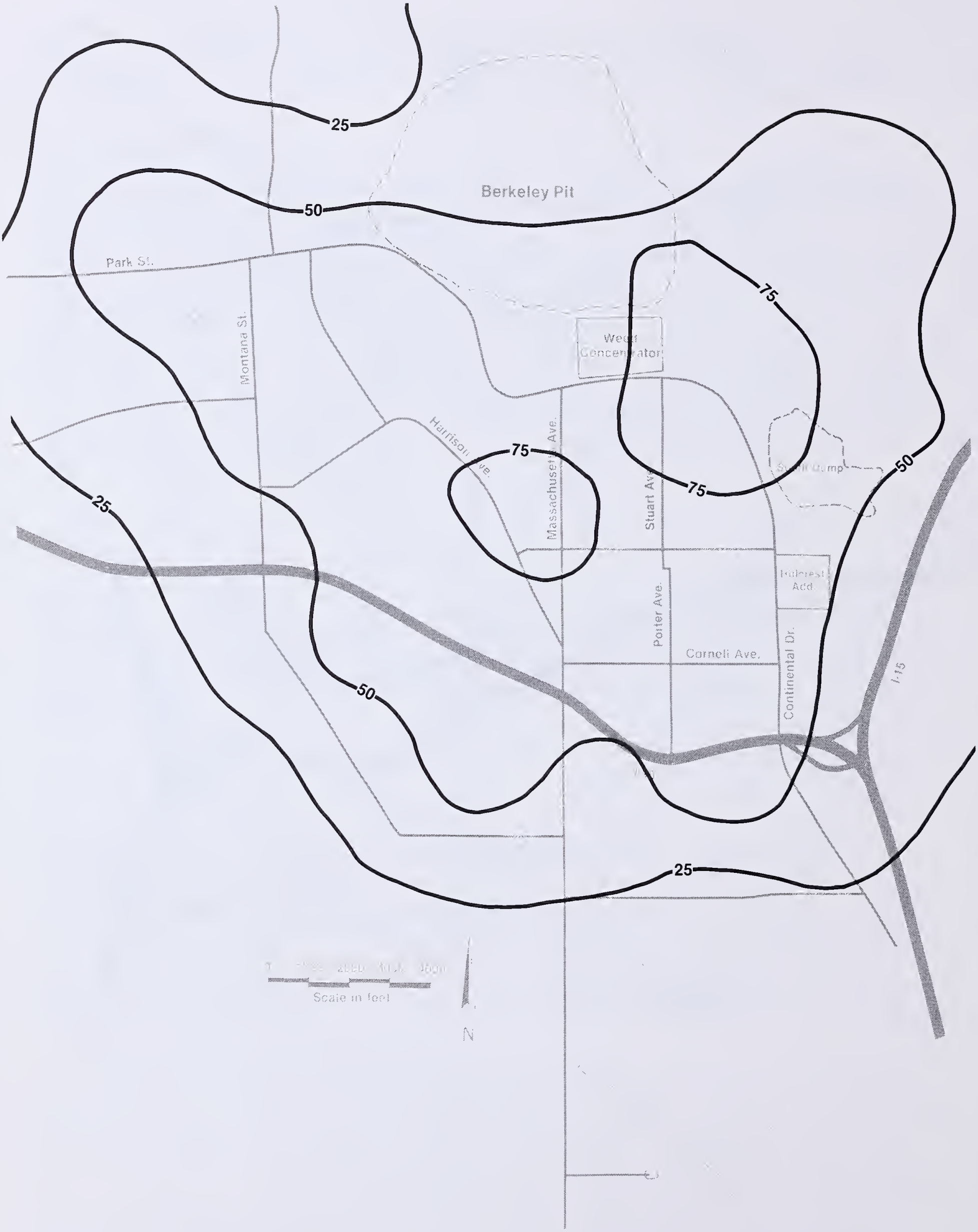


FIGURE III-4.--Predicted summer 1985 total suspended (TSP) levels.

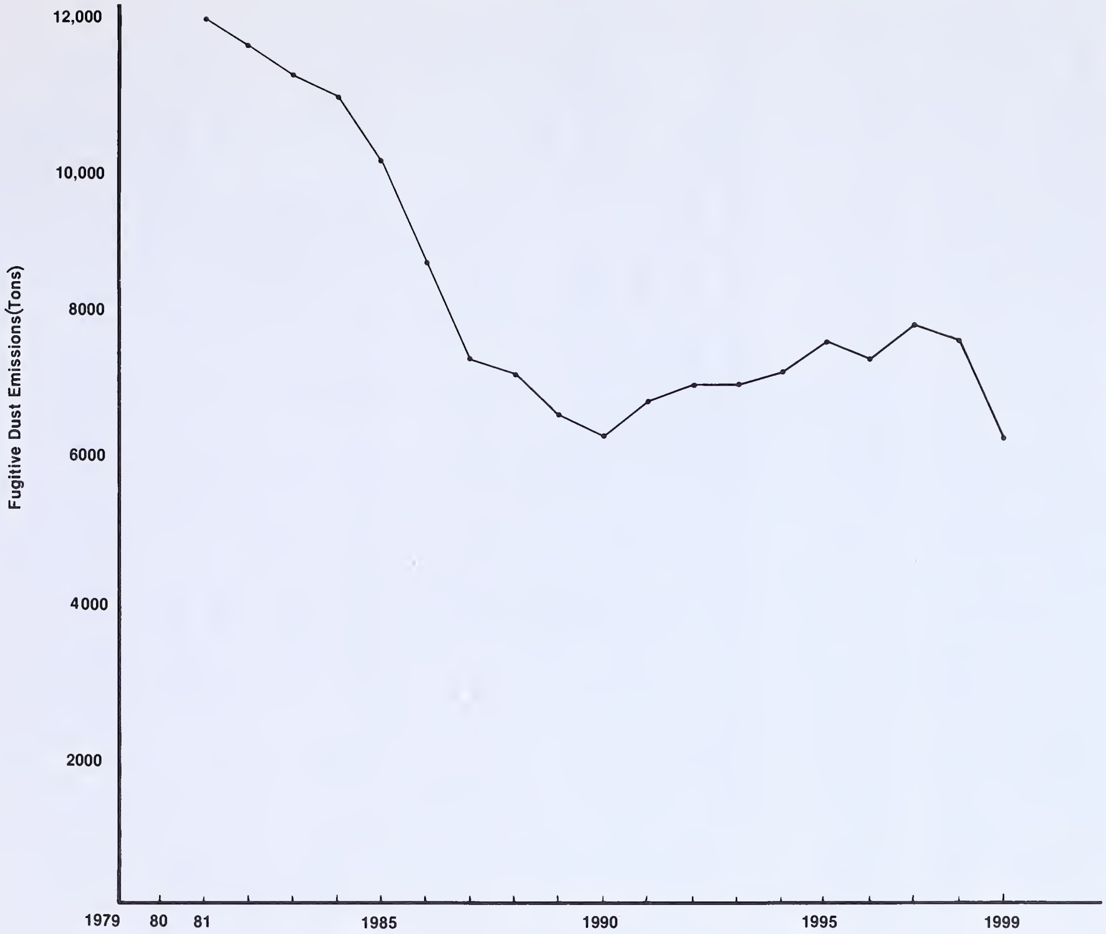


FIGURE III-5.--Estimated fugitive dust emissions from the Anaconda Company's Butte mining operations, 1979-1999.

The predicted TSP levels would probably be in compliance with the Federal and Montana ambient air quality standards for the primary annual average. Present modeling techniques do not permit the estimation of maximum 24-hour concentrations; therefore, it is not known whether this standard would be exceeded. Treating the haul roads with a dust suppressant would reduce fugitive dust (see chapter IV, Technological Alternatives).

The reduction in diesel haul truck use may reduce cancer death rates, but this reduction would not be seen for some 20 to 30 years (Montana Air Quality Bureau, 1981).

Requiring the work force to use dust masks and ear plugs, as appropriate, would reduce the potential health effects from dust and noise in the mining area.

TABLE III-5.--Diesel emissions from Anaconda operations, 1980-1999

A. Annual average diesel emissions, 1980-1984

[Source: U.S. Environmental Protection Agency (1976, p.3.2.7-3)]

Source	Fuel Consumption (Gallons)	Pollutant Emission (Tons/Year)						
		Particulate	CO	HC	NO_x	SO_2	Aldehydes	Organic Acids
Haul Trucks[1]	6,700,000	84.0	1273	489	1172	191	18.4	23
Other Trucks	424,000[2]	3.8	20	6.4	111	6.6	1.6	---[3]
Dozers--Track Type	500,000[2]	6.3	22	6.3	83	7.8	1.6	---
Motor Patrols	240,000[2]	2.7	9.4	2.1	45	3.7	0.5	---
Loaders	132,000[2]	1.9	6.3	2.1	27	2.0	0.5	---
Misc. (Drills, Compressors, etc.)	392,000[2]	5.9	18	6.8	97	6.1	1.3	---
TOTAL	8,388,000	105	1349	513	1535	217	74	23

[1] Emission factor for 4-stroke switching locomotive used [U.S. Environmental Protection Agency (1976, p.3.2.2-2) as recommended by EPA (David Kircher, oral commun., August 20, 1980 and Chuck Masser, oral commun., August 21,1980).

[2] Usage figures from ERT (1978).

[3] No emission factor available.

TABLE III-5 (con't).--Diesel emissions from Anaconda operation, 1980-1999

B. Annual average pollutant emissions (tons/year), 1985-1989[4]

	Diesel Consumption (Gallons)	Particulate	CO	HC	NO_x	SO_2	Aldehydes	Organic Acids
Haul Trucks	3,010,000	38	572	220	737	86	8.3	10.5
Other Vehicles (see table 1)	1,690,000	21	76	24	360	26	5.5	---[3]
TOTAL	4,700,000	59	648	244	1097	112	13.8	10.5

C. Annual average pollutant emissions (tons/year), 1990-1994[4]

	Diesel Consumption (Gallons)	Particulate	CO	HC	NO_x	SO_2	Aldehydes	Organic Acids
Haul Trucks	1,010,000	13	192	74	247	29	2.8	3.5
Other Vehicles (see table 1)	1,690,000	21	76	24	360	26	5.5	---
TOTAL	2,700,000	34	268	98	607	55	8.3	3.5

D. Annual average pollutant emissions (tons/year), 1995-1999[4]

	Diesel Consumption (Gallons)	Particulate	CO	HC	NO_x	SO_2	Aldehydes	Organic Acids
Haul Trucks	2,210,000	27	420	161	541	63	6.1	7.7
Other Vehicles (see table 1)	1,690,000	21	76	24	360	26	5.5	---
TOTAL	3,900,000	48	496	185	901	89	11.6	7.7

[4] Assumption: diesel fuel consumption for all vehicles except haul trucks remains constant.

I. SOCIAL CONDITIONS

1. Population

The population that would be most affected by the proposed action lives in the area near the south dump. A random sample of residents in this "study area" (see chapter II, Sociology) was interviewed to determine attitudes toward south dump operations. The study area was divided into two "subareas" to determine if people closer to the south dump responded differently than those farther from the dump. Residents outside this study area were not surveyed; therefore, it is not known whether the attitudes of study area residents are representative of the rest of Butte.

The heads of households in the study area rank concerns for air quality and jobs as the most important criteria in considering the south dump operation. Most prefer that south dump operations be resumed, primarily because they believe it would stimulate jobs in the local economy. However, residents showed considerable concern about the effect of the dump on property values and air quality.

Seven out of ten heads of households in the study area believe the value of their homes will decrease if the permit for the south dump is granted. Although the effect of the dump on property values is expected to be slight at most, and temporary in any event, (see Land Use), residents' concern about loss of property value may cause anxiety. Twenty-two percent of the heads of households in the subarea closer to the south dump, and 17 percent of the heads of households in the subarea farther from the dump, felt their willingness to stay in their neighborhood would be affected by the proposed action. The overwhelming reason given was their judgment that the south dump would be a nuisance and a health hazard.

It is not known how many people would actually move as a result of these perceived impacts; however, wanting to move as a result of a real or perceived impact would be an indirect impact of the proposed action. Most of those who stated that their willingness to stay in their neighborhood would be affected are long time residents and regard the area as their home. This would weigh heavily in a decison to move. The study area has a high proportion of homeowners; residents are committed to staying in the area.

Twenty-five percent of the heads of households in the study area listed dust pollution as a negative impact of previous south dump operations. A similar proportion of residents could be expected to be concerned about dust from resumed dumping, both as a nuisance and a potential health hazard. However, the dump would not greatly increase dust in residential areas (see Air Quality). The belief that air quality would deteriorate would be an indirect result of the proposed action. Resumed operations at the south dump could cause concern about air quality among some area residents. The most serious reservations to the south dump operations come from those living in the subarea closer to the dump and from families with children under 19. When asked to rank three possible mining options according to what would be best for their immediate family, only 20 percent of the households favored denying a permit for the south dump. When asked to rank the same options according to what would be best for their community, only 10 percent favored denying a permit for the south dump. This indicates that although most of the people in the study area are concerned about physical impacts of the dump, most appear willing to accept those impacts.

Some residents near the south dump would probably consider noise a problem from renewed dumping (see Esthetics).

Renewed use of the south dump would not elicit as much controversy as the dumping which began in 1976; the activity is not new to the area and the residents nearby, and the activity would not surprise as many residents. A public meeting was held and much public awareness was generated by the Hillcrest lawsuit.

The proposed action would not change current trends in the size, age structure, or sex characteristics of Butte's population because migration would not be affected. Similarly, racial and ethnic composition would not change. As Butte residents age and remain in the community, women will compose an increasing proportion of the population. Average household size will decline because there will be relatively fewer young families. The distribution of population and housing would not be affected by the proposed action. Patterns of social interaction would not be affected beyond any changes which have already occurred as a result of controversy over the south dump operations.

Once large scale mining ends in Silver Bow County, many of the younger members of the community would migrate out of the county to find employment. A smaller and older population would remain in Butte, continuing a trend that has been occurring since 1920 when population and employment peaked (see fig. III-6).

2. Health and Safety

Accidents at the Berkeley Pit would probably continue to occur at historical rates because the work force would remain essentially the same (Anaconda Copper Co., written commun. to Department of State Lands, June 20, 1980). Ten persons died in accidents at the pit from 1957 through 1979; lost-time accidents numbered 450 from 1957 through 1979. It is possible that some workers would develop silicosis as a result of working at the Butte mine. Between 1960 and 1980, 43 silicosis applications were accepted from the Butte mines; another 61 applications were denied (Anaconda Copper Co., written commun., to DSL, June 12, 1980).

Based on the air quality analysis and other analyses in this chapter, the proposed permit would not result in increased health hazards to Butte residents or mine workers. Chapter II, Air Quality discusses the high rates of cancer and other diseases in Silver Bow County.

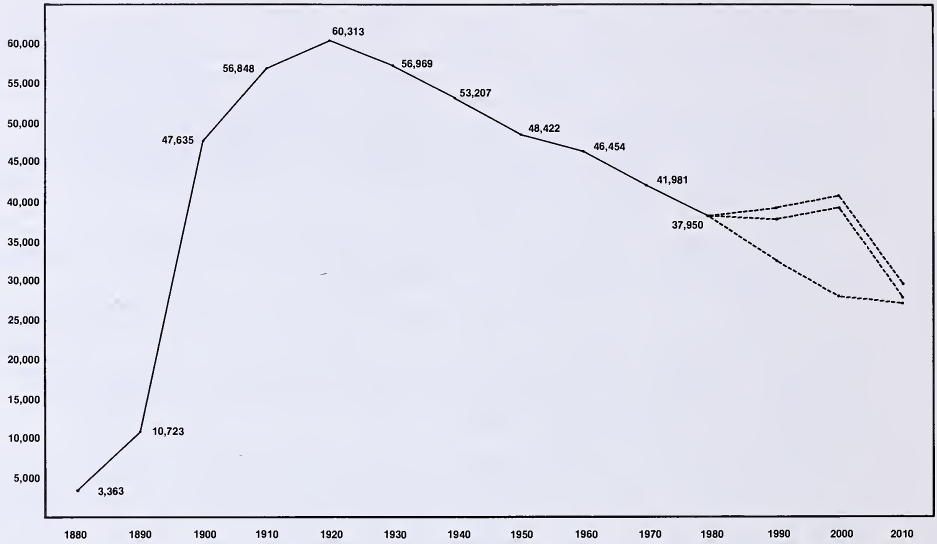


FIGURE III-6.--Population growth in Silver Bow County. Upper dashed line shows projected growth with underground block caving; middle line, with permit approval but no block caving; bottom line, without permit approval.

J. ECONOMICS

1. Employment and Income

Approval of Anaconda's proposal would not directly affect employment or income levels in Silver Bow County. The proposed additional use of the dump area would enable the Anaconda Company to extend the Berkeley Pit to the southeast and thereby maintain the existing level of surface employment until the year 2000. Approval would also maintain the potential to reopen the underground workings, which would significantly increase total employment and income supported by the mine. Without the underground operation, total employment at the mine would decline by 257 to 1,599 jobs by 1985. Mine employment would not change significantly until the mine closed in the year 2000. The 1980-85 mine employment decline, combined with the effects of the closure of the Anaconda Smelter (see chapter II, Economics), would probably offset the employment growth in Silver Bow County that would otherwise occur between 1980 and 1985. Employment in the county is expected to decline from the 1980 total of about 16,100 to about 16,000 jobs in 1985. Thereafter, the recent growth trend of about 900 additional jobs every 5 years is expected to resume, resulting in total employment of about 18,700 in 2000 when the ore body is currently projected to be exhausted and the mine closed.

Until the mine closed, it would probably continue to be the county's major primary industry employer and largest single source of personal income. Additional real income increases of the remaining workers at the mine over the next 20 years could provide some additional growth potential and help offset the loss of earnings from the smelter and reduction in the underground development employment.

The underground block caving operation, which depends on continued ore producion from surface mining, would increase total mine employment by an estimated 422 by 1985 (see chapter I, General Operations). This increase and the derivative increases would result in a 1985 total employment level of 16,700 jobs (on-file staff report). Again, continuation of the recent employment growth trend would produce a total employment figure of 19,400 jobs in 2000. There would be a corresponding population increase. The underground operation may prove to be uneconomic in any case. A decision to go into production could be made by 1985.

Because of the uncertainty associated with projecting employment and income levels 25-30 years from now, the effect of the closure of the mine when the ore body is exhausted, although major, cannot be accurately estimated. Based on the changes during the 1968-79 period, the loss of the 1,599 jobs at the mine and concentrator would cause a secondary loss of approximately 1,100 additional jobs and a corresponding loss of population. The secondary losses could be much less, depending on the number of employees who would be eligible for early retirement; when the Anaconda smelter closed in 1980, 47 percent of the laid-off employees were able to take an early retirement (Billings Gazette, February 6, 1981).

2. Fiscal Conditions

Although approval of the proposed permit would not guarantee that the mine (and hence its taxable value) would continue, it would remove some of the uncertainty surrounding the operation. If the mine produced at the rate currently planned (see table III-6), the price increases forecasted by Chase Econometrics occur, and the molybdenum line is added to the concentrator, the future taxable value of the mine complex would increase substantially. For example, the FY 1990 gross proceeds portion of the company's taxable value would be nearly three times the FY 1980 amount.

The very near future does not look quite so bright for the Butte-Silver Bow government. Because of the recent strike, production during 1980 was about 54 percent of the 1979 figure; therefore, despite the 10-cent annual increase in the average price of copper, the taxable value of the company during FY 1982 will be down by about $640,000 (about 4 percent). Although the price of copper during the first quarter of 1981 was down by about 15 cents from the 1980 average, the new molybdenum production and concentrator facility would more than make up for the reduction in

TABLE III-6.--Summary of projected production and gross value for copper, silver, gold, and molybdenum from the Berkeley Pit, 1981-99

[Does not include underground block caving. Dollar figures are in millions of current dollars. Sources: production--copper and molybdenum, written communication, Anaconda Company; gold and silver, staff analysis; prices--Chase Econometrics Associates (1980a).]

	Copper		Silver		Gold		Molybdenum		
Year	Amount Short tons	Gross value	Amount thousand troy oz	Gross value	Amount thousand troy oz	Gross value	Amount million pounds	Gross value	Total gross value
1981	84,500	$192.7	2,300	$50.4	14.0	$9.3	4.9	$52.0	$304.4
1982	87,000	222.7	2,300	54.2	15.0	10.8	2.5	28.9	316.6
1983	77,000	221.8	2,100	55.6	13.0	10.2	---	---	287.6
1984	111,500	361.3	3,000	86.2	19.0	16.3	---	---	463.8
1985	111,500	405.9	3,000	93.6	19.0	17.8	---	---	517.3
1986	78,000	318.2	2,100	71.6	13.0	13.3	---	---	403.1
1987	84,500	387.0	2,300	88.4	14.0	15.6	---	---	491.0
1988	70,500	362.4	1,000	42.4	8.0	9.7	0.5	9.7	424.2
1989	72,000	414.7	1,000	47.5	8.0	10.6	1.0	21.5	494.3
1990	76,500	494.2	1,000	53.7	8.0	11.5	1.0	23.1	582.5
1991	70,500	489.3	1,000	58.0	8.0	12.6	1.5	37.3	597.2
1992	72,000	534.2	1,000	61.8	8.0	13.7	2.8	74.2	683.9
1993	67,000	532.0	800	52.9	8.0	14.9	2.8	79.4	679.2
1994	64,000	542.7	800	56.8	8.0	16.3	2.8	85.2	701.0
1995	72,000	649.4	800	60.2	8.0	17.7	2.8	90.4	817.7
1996	97,000	931.2	800	64.1	8.0	19.3	2.5	85.9	1,100.5
1997	78,000	798.7	800	68.4	8.0	21.1	2.5	91.6	979.8
1998	105,500	1,150.0	800	72.7	8.0	23.0	0	---	1,245.7
1999	79,000	916.4	800	77.4	6.7	21.0	0	---	1,014.8
TOTAL	1,558,000	$9,924.8	27,700	$1,215.9	201.7	$284.7	25.1	$679.2	$12,104.6

copper value even if the sharp recovery in copper prices projected by Chase Econometrics (1980c) does not occur.

3. Production

Under the proposed mine plan, the Berkeley Pit and southeast pushbacks would produce about 1,558,000 tons of copper, 27.7 million troy ounces of silver, 202,000 troy ounces of gold and 25 million pounds of molybdenum from 1981 to 2000 (table III-6). This represents about 83 percent of the amount of copper, 47 percent of the silver and 55 percent of the gold produced in the previous 19-year period (1961 to 79--see table II-18). Molybdenum would be recovered from the mine for the first time in 1981.

K. COMMUNITY SERVICES AND FACILITIES

The community services and facilities described in chapter II would not be affected, because the proposed action would not significantly change employment and population trends. Most of these services are adequate for Butte's current population and the population projected for 1990.

When large-scale mining ends in Butte in 20 years, the capacity of services required would decline as the population decreases. How well the services would match actual population would depend on what changes are made to these facilities and services in the intervening years. When the mine closed, Butte would contain a larger proportion of persons over 65 and fewer young families, so the human services sector would probably emphasize different programs. For example, there would be less demand for Head Start, day care, and the programs offered by the Community Preventive Health Clinic (Well Child, Prenatal Service, Family Planning, and the Women, Infant, and Children program).

The proposed action would not affect the transportation systems in the Butte area, because no significant population or employment changes would result from approval of the permit application.

L. LAND USE

The proposed post-reclamation land uses for the proposed permit area are watershed protection and small mammal and bird habitat. The currently proposed reclamation plan would result in areas that would be only moderately successful at best in their proposed uses (see Vegetative Reclamation); however, these areas are expected to be as good as much of the land around the dump. The proposed permit area would contain about 3 percent of the pit area, 6 percent of the disturbed area, and 8 percent of the reclamation surface of the mine at the end of mining (see table

II-19). There would not be any indirect changes in land use due to population or economic effects, because the dump would not have a significant effect on either employment or population.

The company's proposal would probably not have a significant adverse effect on land uses outside of the the permit area. A noticable impact on property values in nearby areas would be uncertain. Even if such an effect were to occur, it would be both small and temporary. Total disturbed acreage at the mine would increase by 761 acres, of which 233 acres would be within the proposed permit area (see table II-19).

During the time that dumping occurs, there would be an increase in the external costs (congestion, pollution, and unsightliness) associated with being nearer to an industrial activity without a simultaneous increase in access to the industrial activity. This, along with the projected increase in TSP concentrations (see Air Quality) and its perceived effect on health (see Sociology), and the decrease in the on-site visual quality of some of the nearby residential areas (see Esthetics) could produce a minor reduction in the amount (everything else being equal) that a seller would receive for a residential property in the affected area. The existence of the adverse effect of nearness to industrial activity, air quality changes and on-site visual quality changes on property values is well documented (Li and Brown, 1980). The small number of real estate transactions in the nearby residential areas prevented the empirical determination of the magnitude of such effects on residential property in Butte.

The study by Li and Brown (1980) focused on the impact of microneighborhood variables on housing values in the Boston metropolitan area. The proposed addition to the south dump could reduce the value of property in nearby areas by as much as 5 percent, assuming that:

--households in Butte are as sensitive to nearness to industrial activity as households in the Boston metropoliton area,

--that there is as great a diversity in aesthetic characteristics of residential sites and views in Butte as in Boston, and

--that a small increase in TSP concentrations that would result in a level much lower than the average in Boston would have the same effect in Butte as in Boston.

These assumptions may not hold, and as a result the reduction would likely be less. For example, although 21 percent of the households in the subarea closer to the dump believe that the existing south dump has had an adverse effect on the value of their property (Miller, 1980, p. 49), no taxpayer has appealed his taxable value assessment to the State Tax Appeal Board (Ruth A. Smith, Montana Department of Revenue, written communication, Feb. 24, 1981). Also, despite a noise level during constuction of the existing dump that could be expected to have induced complaints to the local authorities by nearby residents (see Esthetics), no complaints were received. The predicted number of adversely affected households is in exact agreement with the number of households who reported adverse impacts from noise in the neighborhood survey (see Esthetics). The lack of complaints by area residents is an indication that residents of Butte are probably not as sensitive to industrial activity as those in Boston, and as a result, the 5 percent figure is probably an upper limit. The complex interplay of market forces in real estate values could easily mask such a small effect, and it may be impossible to distinguish the impact of the proposed south dump addition from other sources of variation in real estate values. After the dump is completed and reclamation has begun, any impact of the proposed dump would probably become negligible.

In the long term -- 100's or 1000's of years -- the possible failure of the waste water diversion system (see Hydrology) could lead to a reduction in the value of the residential land south of the proposed permit area. Any attempt made to quantify would be highly speculative.

M. RECREATION

The proposed action would not decrease the amount of open space available for recreation because the permit area is privately owned and not open for recreational use at present. Continuation of mining and dumping would not increase the use of urban or non-urban recreation resources because it would not affect the size of the population.

N. CULTURAL RESOURCES

The proposed action would destroy 10 of the 16 historical sites which exist in the area. The sites that would be destroyed include mining prospect holes, the mine dump, a rock pier and concrete slab used for mining, the remains of an old powerline, a concrete bridge, a house foundation, and an automobile graveyard. None of the sites meets the criteria for nomination to the National Register of Historic Places (see chapter II, Cultural Resources); therefore, the loss of the sites is not significant. The historic sites have been photographed--no further mitigation is necessary for these sites, according to Steere (1980, p. 30). The company's proposal would have no impact on archaeological sites because none were found in the project area during the field inventory conducted in 1979. It is not likely that any subsurface archaeological remains would be encountered; the entire area has been disturbed by mining (Steere, 1980, p. 29).

O. ESTHETICS

1. Summary of Impacts

The proposed mining plan and dump configuration would not significantly degrade esthetic values in the Butte area. The existing Anaconda operations have had a great visual impact on the northeast part of the Silver Bow Creek valley; the proposed expansion would increase those impacts but would not introduce new kinds of visual intrusions. The area from which the mine operations could be seen would not be greatly increased. Noise levels would not significantly increase.

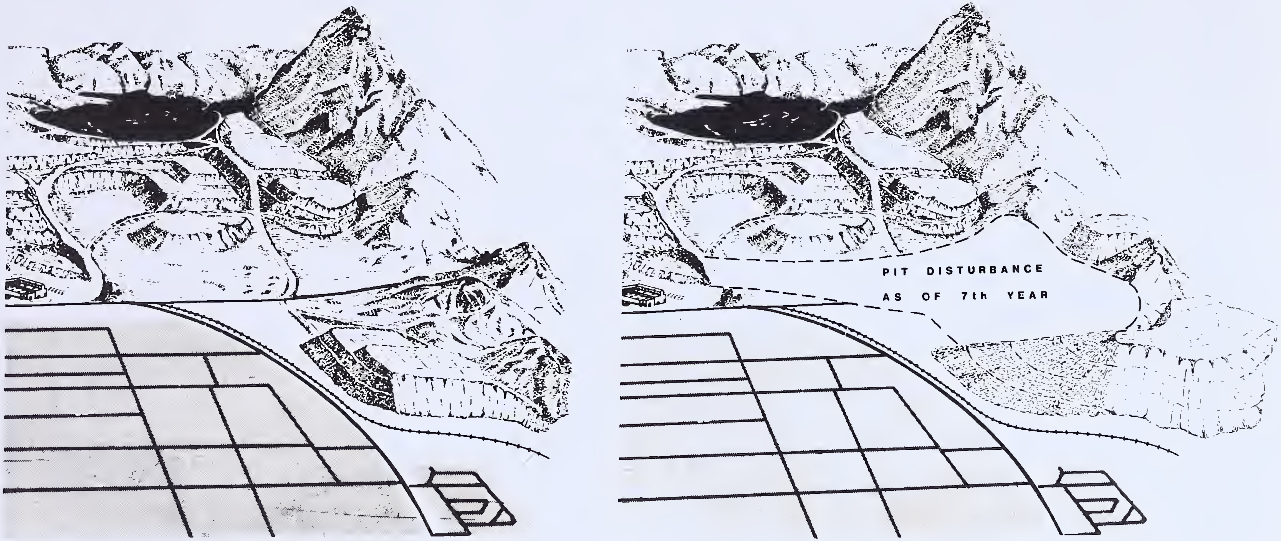
2. Visual Resources

Anaconda proposes to expand the south dump and connect it with the existing East Berkeley backfill. The expanded dump would be four or five times its current area and about three times its current height. Figure III-7 depicts the approximate configuration of the expanded dump. In addition, Anaconda would create a new dump in Elk Park Canyon (the north dump) about the size of the current south dump. The Berkeley Pit would grow to about twice its current size, but because it would not cut into the steeper topography it would be less visible than the highwalls on the west and north sides of the existing pit. Figure I-9 shows a planimetric view of the expanded pit and dumps.

The expansion of the south dump would be the most obvious change. The dump would become more evident from areas where it is now visible and be seen from areas where it is not now visible. Making the dump taller and wider would have a similar effect on an observer as moving about half the distance to the dump. For example, the degree of intrusion felt by someone living 1 mile from the completed dump would be the same, roughly, as the intrusion that person would feel living one-half mile from the current dump.

For those people living close to the dump, primarily in the Hillcrest area, the expansion would be highly noticeable, and for at least some residents it would be a considerable esthetic intrusion (see chapter II, Esthetics). From the perspective of the rest of Butte, however, the completed dump would not greatly increase the already severe visual intrusion created by Anaconda's operations. When regraded and revegetated, the south dump would be much less apparent from most of Butte than the pit highwall. This would probably be the case even assuming only partial revegeation success (see Vegetation) and considerable erosion (see Geomorphology). The north dump would not be highly visible due to its distance from town and partial topographic screening.

Both dumps would be highly noticeable from short segments of Interstate 15. People traveling on I-15 would be exposed to the visual impact for only a few minutes. The expanded south dump would not be highly noticeable to travelers on Interstate 90 because it would not project far above the trees and houses lining the route, and because it would not be within motorists' normal field of view.



Current condition

After dumping is completed

FIGURE III-7.--Approximate configuration of existing south dump and proposed expansion.

Because the pit expansion and the dump would not introduce new kinds of visual impacts, and would not drastically increase the existing kinds of impacts, the esthetic loss would not be significant.

People's attitudes toward the dump would be influenced by their views on mining: people in the mining industry would generally be less bothered by the appearance of the dump than those who do not depend on the company for a livelihood. The dump is a part of Butte's mining history and could be viewed in that context; however, because the dump is a recent development, it does not have the historic importance and esthetic appeal of the old headframes and buildings of uptown Butte.

3. Noise

Noise levels would not significantly increase with the resumption of dumping, based upon a comparison of noise levels measured during south dump construction in 1976-1977 and after cessation of dumping (table II-20). The noise level would continue at about L_{dn} 58dB(A) which would not affect the mental or physical health of Butte residents, based on guidelines established by the U.S Environmental Protection Agency (1974). Noise from the south dump would continue to occasionally interfere with normal outdoor conversation in areas adjacent to the dump. This nuisance would probably last all 6 years of dumping. The population that would be affected by the increased noise has previously been affected by such noise; the impact would not be unique.

Some residents of the study area (see Social Conditions) would probably consider noise a problem if dumping resumed, even though monitoring data indicate that noise levels would not rise significantly. Noise was mentioned as a problem during previous dumping, even though measured noise levels did not increase significantly (see chapter II, Esthetics).

Few people beyond the study area would be affected by noise from the dump because noise levels would decrease greatly with distance from the dump. Seventeen percent of the households in the sub-area closer to the dump mentioned noise as an impact from previous dumping, whereas only 2 percent of the households in the subarea farther from the dump mentioned noise as an impact.

P. SHORT TERM USES VERSUS LONG TERM PRODUCTIVITY

The metal produced out of the mine would be concentrated in Butte and then shipped to Japan for smelting. The metal has been sold to a consortium of Japanese industrial firms. The Anaconda Company will pay a total of about $325 million in state and local taxes. These benefits would be mostly short term, although about $28 million would be added to the State Resource Indemnity Trust Fund.

If the proposed permit area had not been disturbed it would have continued to provide watershed protection, small mammal habitat and limited recreation opportunities. Following reclamation and while the diversion ditches are being maintained, the watershed protection would resume. Use as wildlife habitat and as a recreational area would be limited.

Q. IRREVERSIBLE AND IRRETRIVABLE COMMITMENTS OF RESOURCES

Continuation of the Berkeley mine would result in the extraction of approximately 1.6 million tons of copper, 28 million troy ounces of silver, 200 thousand troy ounces of gold and 25 million pounds of molybdenum. Although only 20-45 percent of the copper eligible for recycling is currently recycled, the potential recovery rate is 75 percent (NATO, 1976). Because of their greater value a greater proportion of the silver and almost all of the gold can be expected to be recycled. Eventually, however, the metals will be dissipated so widely that it would not be economically feasible to recover them.

During the next 20 years the mine would consume 101 million gallons of diesel fuel, 11 million megawatt hours of electricity, and 34 thousand acre-feet of fresh water. Based on the 1977-79 average incidence rate there would be about 10 accidents per year resulting in about 500 loss time days. Over the next 20 years, 7 fatal accidents can be expected.

CHAPTER IV

ALTERNATIVES

This chapter discusses alternatives to approval of Anaconda Copper Company's proposed plan for mining and reclamation at its Berkeley mine under application no. 158.

A. ADMINISTRATIVE ALTERNATIVES

Before Anaconda can use the proposed permit area for mining and dumping, it must obtain a mine operating permit from the Department of State Lands.

The Department must evaluate certain administrative alternatives. These alternatives are: approval of the mine operating permit as proposed, denial of the mine operating permit, taking no action, approval of an operating permit containing modified mining or reclamation plans, and approval of the mine operating permit as proposed with stipulations.

1. Approval of the Mine Operating Permit as Proposed

The environmental effects of approving Anaconda's mining and reclamation plan as proposed are presented in chapter III.

2. Denial of the Proposed Permit

According to Title 82, Chapter 4, Part 3 MCA, the Department may deny the permit if the plan of development, mining, or reclamation conflicts with Montana's air quality and water quality laws, or if the reclamation plan does not provide an acceptable method for reclamation as provided by the Metal Mine Reclamation Act. The Department of State Lands has consulted with the Department of Health and Environmental Sciences to determine whether Anaconda's proposed mining plan and reclamation plan complies with the State's water and air quality laws.

If the permit were denied, the Berkeley mine would probably close after the deep Berkeley Pit was finished in 1986. This is expected to happen because use of the proposed permit area as a waste dump appears to be necessary to allow mining to continue past 1986. Backfilling the Berkeley Pit would not be technically feasible, because the disposal space is needed for the short term and active mining would still be taking place in the pit. Trucking or conveying all waste to existing permit areas north and west of the proposed permit area would not be economically feasible according to Anaconda (written commun., June 20, 1980). According to the company, trucking all of the waste to different areas would increase haulage costs by 9 percent. A dual-belt conveying system capable of handling all waste material would reportedly require too great a capital investment. The truck fleet would also have to be maintained at near current levels to allow the mine to operate when the belts were shut down for repair, maintenance, or moving.

The large capital investment required to reopen the mine after it had been shut down and dismantled would preclude reopening until the real prices of the metals to be recovered rose enough to make an alternative use of the proposed permit area feasible. This might not occur until other worldwide deposits with more favorable conditions were developed.

Environmental effects if the Company's proposal were denied are summarized below:

New disturbance of the landscape would be minimized, because the Berkeley Pit would probably not be expanded much beyond its present limits. The south dump would not be expanded beyond its present size, and the north dump in Elk Park Canyon would not be created.

The company could probably cover the existing south dump with sufficient topsoil and alluvium to allow better revegetation success than possible under the proposed plan, because the existing dump is smaller than the proposed dump. A detailed reclamation plan for the existing south dump is not available, however.

Hydrologic impacts from the existing south dump would be less than those expected from the expanded south dump, because less waste rock would be placed in stream drainages where it could be eroded (see chapter III, Hydrology).

Air quality impacts would continue as described in chapter II until 1986, when the mine would shut down. After the mine closed and disturbed areas were reclaimed, total suspended particulate concentrations would decrease significantly. At that time Butte would likely be in compliance with Federal and State ambient air quality standards.

Closure of the mine would severely affect Butte's economy which depends heavily on the Anaconda Company (see chapter II, Economics). Impacts of mine closure are discussed in chapter III, Economics; those impacts resulting from permit denial would begin to occur in 1986-probably at least several decades sooner than if the permit were approved. These economic effects would probably lead to severe social problems as a result of high unemployment and uncertainty over the future. Most community services and facilities would have excess capacity and a declining tax base. This would lead to problems in maintaining existing systems.

3. No Action

If the Department took no action on Anaconda's permit application by October 1, 1981, the permit would be approved by default (82-4-337 MCA).

4. Approval of Modified Mining or Reclamation Plan

If the proposed plan were unacceptable, the Department may return it to Anaconda with a request that the company submit a modified plan for reclamation. Possible modifications that would reduce the environmental impact of the company's proposal are discussed under Technological Alternatives.

5. Approval of the Proposed Mining and Reclamation Plan with Stipulations

If the proposed plan were unacceptable, the Department may grant the permit with stipulations that would be necessary to meet the requirements for approval. Possible stipulations would include any modifications or additions to the proposed reclamation plan which the Commissioner considers necessary in order to meet requirements of the Montana Metal Mine Reclamation Act.

B. TECHNOLOGICAL ALTERNATIVES

Anaconda could or may adopt any of the following technical modifications of its proposed mining and reclamation plan.

The Anaconda Company could adopt any of the following technical modifications of its proposed mining and reclamation plan.

1. General Modification of the Proposed Permit (Alternative B)

Anaconda is evaluating an alternative (called Alternative B in this EIS) in which about one-fourth of the existing truck fleet would be replaced with a single-belt conveying system. This would require a revised mine plan that would start at the east edge of the southeast pushback area and mine west instead of east, as currently proposed. This alternative would allow the company to mine additional area and recover copper and molybdenum simultaneously, greatly increasing the amount of metal produced (table IV-1). The alternative would reduce truck usage, extend the mine life about 10 years, reduce the height of the south dump from that proposed, and allow reclamation to begin about 1 year earlier.

Although neither employment nor income levels would be significantly different than under the proposal, the jobs would remain for an additional 10 years. This would delay, but not prevent, the effects of the closure of the mine discussed in chapter III.

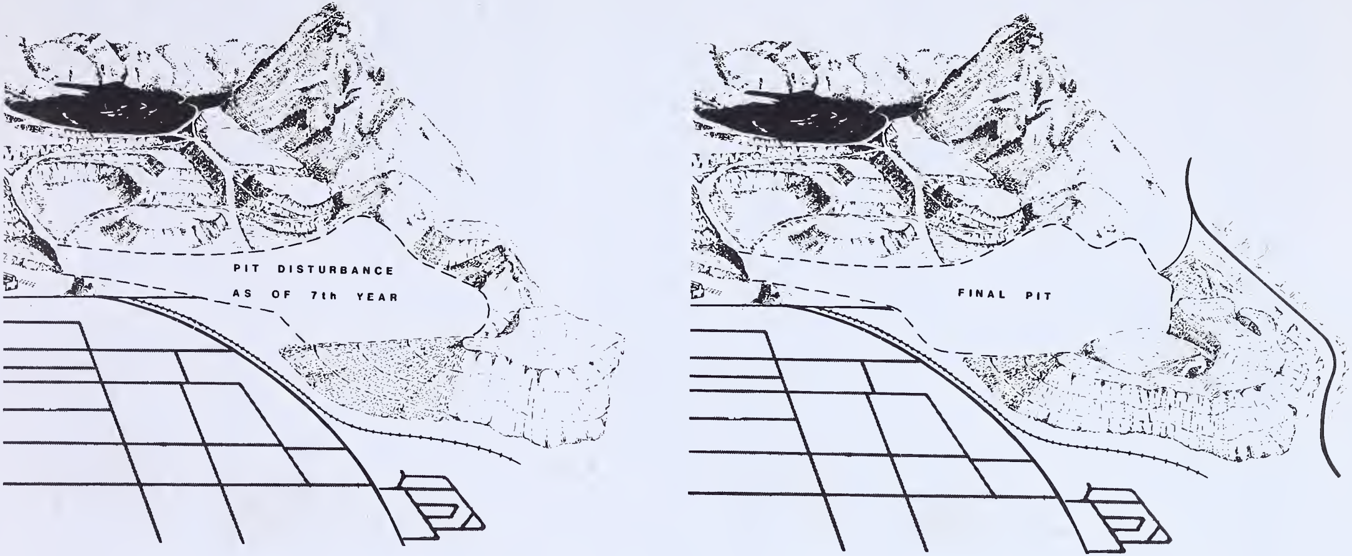
This alternative would also require a capital investment approximately $7 million more than the currently planned system changes needed to convey alluvium to the permit 158 area.

Because much of the alluvium would be conveyed to the waste dump north of the pit rather than to the permit 158 area, the final height of the southwest corner of the dump would be about 125 feet lower than what would result from the proposed permit. The final dump under this alternative would resemble a gradually plunging ridge with a high elevation of

TABLE IV-1.--Projected production and gross value for metal production from the Berkeley Pit, 1981-2010, Alternative B mine plan without Kelly block-caving

[Dollar figures are in millions of current dollars. Sources: production--copper and molybdenum, written communication, Anaconda Company; gold and silver, staff analysis. Prices--Chase Econometrics Associates (1980a)]

	Copper		Silver		Gold		Molybdenum		
Year	Amount Short tons	Gross value	Amount thousand troy oz.	Gross value	Amount thousand troy oz.	Gross value	Amount million pounds	Gross value	Total gross value
1981	70,000	$159.6	1,900	$41.6	11.9	$7.9	4.9	$52.0	$261.1
1982	70,000	179.2	1,900	44.8	11.9	8.6	2.5	28.9	261.5
1983	60,000	172.8	1,600	42.3	10.2	8.0	0	0	223.1
1984	70,000	226.8	1,900	54.6	11.9	10.2	1.6	22.0	313.6
1985	70,000	254.8	1,900	59.3	11.9	11.1	4.7	70.4	395.6
1986	55,000	204.0	1,500	51.2	9.4	9.6	4.6	75.1	339.9
1987	60,000	274.8	1,600	61.5	10.2	11.3	4.0	71.2	418.8
1988	40,000	205.6	400	16.9	4.0	4.8	8.8	170.7	398.0
1989	40,000	230.4	400	19.0	4.0	5.3	9.8	210.7	465.4
1990	35,000	226.1	400	21.5	4.0	5.8	10.0	230.5	483.9
1991	35,000	242.9	400	23.2	4.0	6.3	9.3	231.5	503.9
1992	40,000	296.8	400	24.7	4.0	6.8	11.1	294.3	622.6
1993	40,000	317.6	400	26.4	4.0	7.5	13.0	368.6	720.1
1994	45,000	381.6	400	28.4	4.0	8.1	11.6	353.0	771.1
1995	45,000	405.9	400	30.1	4.0	8.9	10.0	322.7	767.6
1996	50,000	480.0	400	32.0	4.0	9.7	8.7	298.8	820.5
1997	50,000	512.0	400	34.2	4.0	10.5	7.5	274.9	831.6
1998	45,000	490.5	1,000	90.8	8.0	23.0	4.4	171.4	775.7
1999	50,000	580.0	1,000	96.7	8.0	25.0	1.5	62.2	763.9
2000	75,000	930.0	1,000	103.2	8.0	27.3	0	0	1,060.5
2001	80,000	1,060.8	1,000	110.3	8.0	29.1	0	0	1,200.2
2002	75,000	1,063.5	1,000	117.9	8.0	31.2	0	0	1,212.6
2003	80,000	1,212.8	1,000	126.1	8.0	33.3	0	0	1,372.2
2004	80,000	1,296.0	1,000	134.8	8.0	35.6	0	0	1,466.4
2005	75,000	1,299.0	1,000	144.1	8.0	38.1	0	0	1,481.2
2006	80,000	1,481.6	1,000	154.0	8.0	40.7	0	0	1,676.3
2007	90,000	1,782.0	1,000	164.6	8.0	43.5	0	0	1,990.1
2008	90,000	1,904.4	1,000	176.0	8.0	46.5	0	0	2,126.9
2009	85,000	1,922.7	1,000	188.1	8.0	49.7	0	0	2,160.5
2010	75,000	1,813.5	1,000	201.1	8.0	53.1	0	0	2,067.7
TOTAL	1,855,000	$21,607.7	29,300	$2,419.4	221.4	$616.5	128.0	$3,308.9	$27,952.5



Proposed expanded dump

Alternative B dump

FIGURE IV-1.--Approximate configuration of proposed expanded dump and Alternative B dump.
]

about 6,250 feet at the north end of the Continental East Pit and an elevation over the existing south dump of about 5,975 feet (fig. IV-1). Because slope lengths would be about 300 feet less, erosion from the critical south and west dump slopes would be about 15-20 percent less than under the proposal. This would enhance revegetation success. Erosion rates on the west and south facing slopes would still probably be greater than 5 tons/acre/year for decades.

The dump faces would still be relatively uniform, but the dump top would not present as strong an unnatural line due to the reduced dump height as proposed in Alternative B. From all except the closest residential area, the top of the dump would be seen against hills instead of sky, lessening the visual contrast compared to the company's proposal.

Other environmental effects would be similar to those expected under the proposal. Although some of the dumping would be farther from town, air quality would not measurably improve because the haul trucks would have to travel farther and climb steeper grades, thus consuming more fuel and emitting more pollutants.

The Elk Park Canyon dump (the northern unit of the permit 158 area) might not be needed in Alternative B possibly eliminating further disturbance in that area.

Alluvium hauled to the north would be available for reclaiming existing permit areas 30 and 30A (waste rock dumps, leach pads, and tailings ponds). This would probably cost less than salvaging alluvium dumped in the pit, which might be necessary under the proposed plan.

2. Geomorphology

In order to lower erosion rates on the dump slopes below 5 tons/acre/year (the most optimistic estimate of the rate of soil formation), the dump slopes could be divided into smaller segments by using more large terraces than the company proposes. The terraces would have to be spaced a maximum of 100 feet apart to reduce the slope lengths enough to bring erosion rates below 5 tons/acre/year. Up to 12 terraces would have to be built on the longer slopes of the proposed waste dump, compared to three terraces in the company's proposal. Under Alternative B (conveying more material to the north), a maximum of 9 terraces would be required on the longest slopes.

The terraces would have to be designed and maintained to divert runoff water away from reclaimed areas and prevent severe gully erosion. The terraces would need to be a minimum of 6 feet wide. They could be sloped to carry runoff water to a point where the dumps intercept the natural landscape. The water could then be discharged into ditches. A second method would be to build drop structures periodically down the face of the dump, directing runoff water off the terraces. These drop structures could be made up of riprap, concrete, or some combination of both. Riprap alone is not recommended, because runoff water could easily infiltrate into the sandy underlying alluvium causing piping and channeling within the alluvium and leading to failure of the drop structure (Larry Ivanovitch, Montana Department of Highway, oral commun., April 15, 1981). The Department of Highways has had success with pouring concrete over riprap, because the riprap gives needed rigidity to the concrete.

The terraces could be designed to effectively reduce erosion rates possibly for several centuries. After that, the terraces would probably fill with sediment if not maintained. It would be almost impossible to design the terraces and runoff control features so that they were maintenance-free. Without proper maintenance, severe gully erosion in isolated areas of the dump could be expected.

Lowering the dump slopes to about 20 percent (versus the proposed 44.5 percent) would probably be necessary to prevent the formation of gullies. This would severely limit the height and the amount of waste rock that could be placed in the waste dumps. Because the area available for dumping waste rock is very limited, more waste rock would have to be moved elsewhere, which might not be economically feasible (see Administrative Alternatives, Denial of the Proposed Permit).

The company proposes to maintain the erosion control terraces until vegetation is well established, and then fill them in. Alternatively, the company could be required to continue maintaining the terraces in order to minimize erosion and optimize reclamation success. Sediment that accumulated in the terraces would have to be removed every few years to avoid forcing collected runoff water over the edge of the terraces and down the dump face. This would cause large gullies. Heavy equipment would be required to remove the accumulated sediment. Filling the terraces as proposed would be preferable to not properly maintaining them.

3. Soils, Alluvium, and Vegetation

The company could apply lime (calcium carbonate) to the soil and alluvial material on the slopes at a rate of 1 ton/acre. This would create neutral or near-neutral conditions in the surface zone of the material. By doing so, the availability of potentially toxic metals to plants would be greatly decreased, and localized vegetation failures due to toxicity would be reduced.

The droughty nature of the soil and alluvium could be mitigated in several ways. Stockyard manure or salvaged soil from the Columbia Gardens area could be selectively used on anticipated problem areas such as south and west slopes. A ground alfalfa hay (or other comparable material) could also be selectively applied to increase the organic matter content in the surface of the material.

The company could commit to a supplemental fertilization program. The sandy nature of the soil and alluvial material as well as the lack of appreciable organic matter would affect its ability to adsorb and store mineral nutrients. Therefore, after the first few growing seasons, the majority of the nutrients that the company applied initially (and were not utilized by the plants), would probably be leached out of the rooting zone. Supplemental fertilizer would be beneficial until the vegetation is well established and organic matter began to accumulate in the soil and alluvium.

Soil could be salvaged in two lifts instead of the proposed one lift. Only the surface soil horizon containing desirable organic matter would be removed during the first lift. If a subsurface horizon is present with an accumulation of clay, this may also be removed during the first lift along with the surface material. The second lift would take the remaining soil material that has desirable properties for reclamation. The two lifts would be stored separately. By use of a two lift method, the surface horizon(s) could be reserved for placement on dump surfaces (above the alluvium or subsoil materials). This would increase the water and nutrient retention capacity, and therefore increase the chances of vegetation success.

The company could be required to identify and separate uncontaminated (non-toxic) waste rock as it is removed from the Berkeley Pit, and stockpile it separately. This material could then be mixed with the alluvium as it is placed on the slopes. This procedure wuld allow for greater stabilization of the alluvium-veneered dump slopes and therefore would increase vegetation success.

4. Hydrology

a. Locating waste material out of any drainages

If waste rock and alluvium were placed north of the Berkeley Pit instead of in the proposed dumps, the hydrologic problems related to diversion system failure discussed in chapter III, Hydrology would be largely avoided. Sediment eroded from the dump and any poor quality water generated by the dump would eventually end up in the Berkeley Pit if the dumps were positioned above the pit. The area north of the Berkeley Pit and west of Walkerville does not have well-developed drainages, and would therefore be a better site for waste disposal.

This would increase Anaconda's operating costs and may be uneconomical (see Administrative Alternatives, Denial of the Proposed permit).

b. Seal off old underground workings

Oxygen could be prevented from coming in contact with pyrite in old underground workings by sealing them off. This would reduce the acidity of the Berkeley Pit water once the pit filled with water at the end of mine life (John Sonderegger, Montana Bureau of Mines and Geology, written commun., November 3, 1980). Concentrator mill tailings less than 200 mesh size could be used to seal the Berkeley Pit (Anaconda Copper Company, written commun., September 19, 1980).

c. Divert surface waters into Berkeley Pit

The Company has proposed that at the end of mine life all contaminated surface waters from the abandoned Berkeley operation be directed into the Berkeley Pit. Additional uncontaminated surface water could also be directed from Yankee Doodle Creek and Silver Bow Creek into the Berkeley Pit. This would help to dilute the concentration of dissolved constituents (including metals) in the pit water. Ground water of the Silver Bow Basin that is adjacent to the pit would probably receive considerable amounts of water from the filled Berkeley Pit; therefore, a reduction in dissolved constituents in the pit water would reduce the impacts on the ground water and possibly surface waters of Silver Bow Creek (see chapter III, Hydrology).

The additional surface waters directed into the Pit could add oxygen to the Berkeley Pit which could help settle out dissolved metals (John Sonderegger, oral commun., March 16, 1981).

If a lot of relatively good quality surface water were added to the Berkeley Pit water, total dissolved solids of the lake water could be 500 milligrams/liter or less. The lake water would also probably be less acidic, tending towards a more neutral range (6.0-7.0 pH). That would be fairly good quality water. Isolated metal values may be slightly elevated, but would probably not be a major problem if the water were as good as indicated by the above estimate.

d. Other methods of improving pit water quality

Addition of lime to the Berkeley Pit waters after the end of mine life would raise the pH of the water and as a result metals would be precipitated out. Anaconda Copper Company has its own source of lime at Brown's Quarry. The Company currently uses lime for water clarification at the concentrator tailings ponds and the Warm Springs settling ponds. Lime would probably have to be periodically added to the pit water to maintain its effectiveness.

Anaconda could take water quality samples from the Berkeley Pit water to determine whether undisturbed surface water in Yankee Doodle Creek and Silver Bow Creek should be diverted into the pit to dilute pollutants. This would be necessary only if Anaconda diverted those streams around the pit.

e. Long term maintenance of diversion systems

The company could periodically maintain the diversion systems around and through the dumps, or to post bond to permanently fund such maintenance. This would prevent contaminated water from the dumps from reaching offsite waterways. This would include unplugging clogged pipes, removing accumulated sediment, and repairing breached ditches or failed pipes.

5. Air Quality

Treatment of the haul roads with a dust suppressant such as calcium chloride would reduce fugitive dust arising from traffic. According to the U.S. Environmental Protection Agency (1980), this treatment could reduce the fugitive dust emissions from 9.1 lb/VMT at present to about 2.7 lb/VMT. Consequently, about 70 percent of the dust from haul roads would be eliminated. This treatment would also reduce road maintenance, i.e., road grader operation, and would reduce fugitive dust emissions and gaseous and particulate emissions from diesel fuel consumed by the graders.

6. Esthetics

If the face of the dump were redesigned to have some topographic variety, the esthetically undesirable uniformity of the dump would be reduced. This could be difficult to implement due to engineering and erosion control constraints.

C. POST-PERMIT MANAGEMENT ALTERNATIVES OF THE DEPARTMENT

1. Modification of Reclamation Plan According to 82-4-337(3) MCA

The reclamation plan may be modified by the Department, upon proper application of the permitee or Department, after timely notice and opportunity for hearing, at any time during the term of the permit and for any of the following reasons:

a. to modify the requirements so they will not conflict with existing laws;

b. when the previously adopted reclamation plan is impossible or impracticable to implement and maintain;

c. when significant environmental problem situations are revealed by field inspection.

2. Suspension of a Permit

A permit that has been granted by the Department may be suspended for failure to comply with the reclamation plan or other provisions of the Metal Mine Reclamation Act. Before a permit is suspended the Department may issue a notice of noncompliance specifying the changes to be made and the time limit for doing so. If the company does not comply with the terms of the notice of noncompliance or the order of suspension within the time allowed, the permit may be revoked and the performance bond forfeited to the Department (82-4-362 MCA).

CHAPTER V

CONSULTATION AND COORDINATION

A. DEVELOPMENT OF THIS STATEMENT

The following individuals, agencies, and companies (other than those cited in the text) provided information used to analyze Anaconda Copper Company's proposed permit application.

Government Agencies

Montana Bureau of Mines and Geology (Butte)

Montana Department of Fish, Wildlife, and Parks (Helena)

Montana Department of Health and Environmental Sciences (Helena)

U.S. Department of Agriculture, Forest Service (Butte)

Consolidated City and County of Butte-Silver Bow

Butte-Silver Bow Planning Board

Nongovernment

Anaconda Copper Company

Bureau of Business and Economic Research, University of Montana

The following Department of State Lands staff contributed to the preparation of this environmental impact statement.

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The Department appreciates the assistance of Anaconda Copper Company, which provided provided the EIS team with information and arranged visits to the mine.

B. REVIEW OF THIS STATEMENT

In accordance with the Department's regulations governing environmental impact statements (EIS's), copies of this draft EIS will be made available to the public for comments and suggestions. All comments received will be carefully considered in the preparation of a final EIS. Written comments should be sent to Gareth Moon, Commissioner, Department of State Lands, Capitol Station, Helena, MT 59620.

The draft EIS is available for review in the following places:

- Montana Department of State Lands, 1625 11th Avenue, Helena, Montana
- Butte Public Library, West Broadway Street, Butte, Mont.
- Lewis and Clark Library, 120 South Last Chance Mall, Helena, Mont.
- Parmley Billings Public Library, 510 North Broadway, Billings, Mont.

A limited number of copies are available on request from the Department of State Lands, Capitol Station, Helena, MT 59620.

CHAPTER VI

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APPENDIX O-1

A. ACOUSTIC NOMENCLATURE

The range of sound pressures that can be heard by humans is very large. This range varies from two ten-thousand-millionths (2×10^{-10}) of an atmosphere for sound barely audible to humans to two-thousandths (2×10^{-3}) of an atmosphere for sounds which are so loud as to be painful. The decibel (dB) notation is used to present sound levels over this wide physical range. Essentially, the decibel unit compresses this range to a workable range using logarithms. It is defined as:

$$\text{Sound pressure level (dB)} = 20 \log_{10}\left(\frac{P}{P_o}\right)$$

where P_o a reference sound pressure required for a minimum sensation of hearing; = 20 micronewtons/meter^2 and p is the sound pressure level being converted to decibels

Zero decibels is assigned to the minimum level and 140 decibels to sound which is painful. Thus a range of more than one million-fold is expressed on a scale of zero to 140.

The human ear does not perceive sound at low frequencies in the same manner as those at higher frequencies. Sounds of equal intensity at low frequency do not seem as loud as those at higher frequencies. The A-weighted network is provided in sound analysis systems to simulate the human ear. A-weighted sound levels are expressed in units of dB(A). These levels in dB are used by the engineer to evaluate hearing damage risk (OSHA) or community annoyance impact and are also used in Federal, State, and local noise guidelines and ordinances. The term "sound level" as used in this report, is understood to represent the A-weighted sound level unless otherwise noted.

Sound is not constant in time. Statistical analysis is used to describe the temporal distribution of sound and to compute single number descriptors for the time-varying sound. This report contains the statistical sound levels:

L_{eq} --This is the equivalent sound level which provides an equal amount of acoustical energy as the time-varying sound.

L_x --This is the level exceeded "x" percent of the time during the sample period where L"$_x$" is:

L_1 --the maximum sound level;

L_{10} --the "intrusive" sound level;

L_{50} --the "median" sound level;

L_{90} --the "residual" sound level; and

L_{99} --the minimum sound level.

L_d --Day Sound Level, L_{eq}, for the daytime period (0700-2200) only.

L_n --Night Sound Level, L_{eq}, for the nighttime period (2200-0700) only.

L_{dn} --Day-Night Sound Level, a weighted average defined as:

$$L_{dn} = 10 \log_{10} ([15 \times 10^{L_d/10} + 9 \times 10^{(L_n+10)/10}]/24)$$

Note: A 10 dB correction factor is added to the nighttime equivalent sound level when computing L_{dn}.

B. FEDERAL GUIDELINES AND REGULATION

The U.S. Environmental Protection Agency (EPA) has established guidelines for limites of L_{dn} requisite for the protection of public health and welfare (U.S. Environmental Protection Agency, 1974).

According to EPA guidelines, outdoor ambient sound levels, L_{dn}, below 55 dB will not degrade public health and welfare.

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